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# Evening Meeting.

Monday, May 19th, 1862.

His Grace the DUKE OF SOMERSET, First Lord of the Admiralty, in the Chair.

## THE CHARACTER OF GUN BEST ADAPTED FOR NAVAL WARFARE, AS GATHERED FROM THE VARIOUS PLANS OF GUNS PROPOSED.

By Captain E. GARDINER FISHBOURNE, R.N. C.B.

MY LORD DUKE, AND GENTLEMEN,—

I will not take up the time of the evening with apologies for having undertaken to read this paper: let it suffice that, having been captivated by the beauty of the mechanism of the Armstrong gun, its great ranges, reported accuracy, and the undoubted genius of its constructor, I incidentally gave in this place a too unqualified assent to all that had been claimed for it. Finding that in some respects I had been misinformed on a point of such national importance, it became my duty to give equal publicity to my withdrawal of that assent.

To compare results obtained from an elaborately finished rifled gun, fitted with an accurate sight, a nicely adjusted missile, added to a carefully devised carriage, and elevating screw, with results obtained from an ordinary smooth-bore gun, without any of those advantages, firing an imperfect missile leaving a large amount of windage, yet, on that comparison, to found an estimate of the rifle *principle*, as contrasted with that of the smooth bore, was obviously incorrect—still more incorrect to give practice

at ranges, that were as favourable to the rifled gun, as they were unfavourable to the smooth bore. *No fair* estimate of the *principle* could have been arrived at, till equal genius had been expended in developing the merits of each *principle*.

The evils that arise from such a course, even in holiday practice, are great, but they are all intensified by the circumstances of warfare, owing to which, as Colonel Fox has justly observed, the inaccuracies of the man are as 20 to 1 of those which result from defects in his rifle; and if so in the field, how much more so afloat, where, in addition to the causes of inaccuracy enumerated by that officer, are superadded the motions of the ship. How *very* incorrect then must it be to consider a gun apart from the normal circumstances under which it will be used; yet, such has been done; a comparative estimate of the *principle* of the rifle, and of *that* of the smooth bore, has been made irrespective of that which, when the guns and objects are in motion and the distances unknown, must rule their useful qualities, viz. the form of trajectory and the straightness of ricochet.

For the inaccuracies arising from motion, whether it be that of pitching, rolling, or of transit across line of fire, or of rapid change of distances, or smallness of height of the object fired at, are best provided against by a flat trajectory and a ball that will ricochet straight—these will be more nearly attained in proportion as the time of flight, for the required distance, is reduced, and the ball more perfectly spherical, while the smashing effect will be increased in a higher ratio than even the square of the increased velocity.

Greater accuracy with the same guns, &c. at known distances, with heavier charges, arising from the greater velocity of projectile, is so well known and admitted, as not to need proof or explanation; but, great as are the other advantages of high charges, they are small as compared with those of a flat trajectory, where the distances are unknown.

A diagram will best illustrate this:—Plate I., fig. 13, represents two trajectories, one, that of a ball with such a velocity that it travels the distance in one second, and subject only to the fall of 16 feet; the other, of a ball that requires two seconds, therefore subject to a fall by gravity of 64 feet.

If no disturbing cause arises, a ship that is but 12 feet high, and there are few so low, will be struck at any point in the trajectory of the ball, with high velocity; whereas a ship 48 feet high or more, will be passed over by the ball having the lower velocity, and only within narrow limits of distance would a ship 30 feet high be struck by it in *its* trajectory.

High charges and high velocities are most valuable for accuracy under the circumstances of *actual* warfare; uniformly so when, as in naval warfare, the changes prevent the distances from being known, and where the varied motions of the gun-platform prevent any tentative process by which the distances might be even approximately estimated.

High velocities are rendered indispensable by the introduction of iron-clad ships. This is clearly shown in tables A and G, from which it appears that the old smooth-bore 68-pounder, with all its defects, is more effective than the carefully devised 110-pounder Armstrong, demonstrated by the greater penetration and greater indentation of the shot of the former.

TABLE A.

Obtained by measurement at Shoeburyness.

| Nature of Gun. | Shot. | Powder. | Penetration. | | Comparative Force of Blow, exclusive of Width. |
|---|---|---|---|---|---|
| | | | Depth. | Width. | |
| | lbs. | lbs. | inches. | inches. | |
| Old 68 ... ... | 68 | 16 | 2¼ | 7½ | 5·06 } Cast Iron Shot. |
| Armstrong .. ... | 110 | 14 | 1½ | — | 2·25 } |
| Ditto... ... ... | 200 | 10 | ¾ | 6½ | 0·56 |
| | Shell. | | | | |
| Old 68 ... .. | 50 | 16 | 1½ | 11 | 2·25 |

FAIRBAIRN TARGET.

TABLE G.

| Nature of Gun. | Distance. | Powder. | Thickness of Plates. | Penetration. | Remarks. |
|---|---|---|---|---|---|
| | yards | lbs. | inches. | inches. | |
| 68-pounder ... | 200 | 16 | 4½ | 2¼ | Obtained at Shoeburyness. |
| ,, | ,, | 20 | ,, | 3 | From H.M.S. Excellent. |
| ,, | ,, | 24 | ,, | 3·4 | |
| *,, | 400 | 16 | 4 | 3 | Wrought iron shot. |
| *,, | ,, | ,, | ,, | went through. | |
| *,, | 600 | 16 | 10 | 1½ | Thornycroft's plates. |
| *Armstrong 80-p.... | ,, | 11 | ,, | 1 | |
| *Ditto 40-p. ... | ,, | 5 | ,, | ¾ | |

* Compiled from official reports.

As it is generally admitted that the highest initial velocities can be obtained only with round shot, it is hardly necessary to offer proof: still the tables B, C, and F, set this forth in a clear light; these show not only that the initial velocities of round shot are greater, but that the time of flight for the most essential ranges is much less; by essential ranges, I mean those within which the iron clothing of ships may be materially damaged, up to 600 yards or more if the plating be thin, still further if the guns be increased in size.

Fig. 13. *Trajectory of Shot having velocities o*

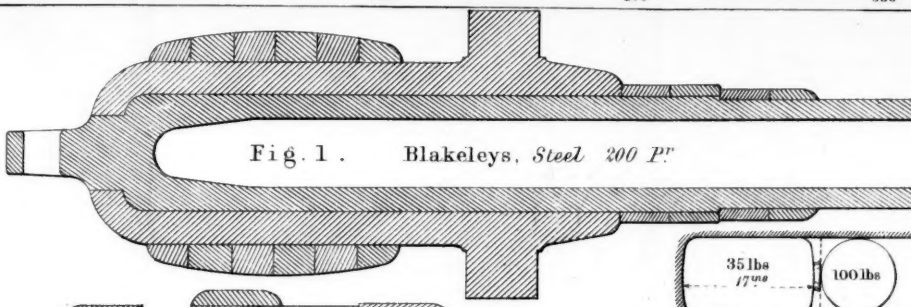



Fig. 1. Blakeleys, *Steel 200 Pr.*

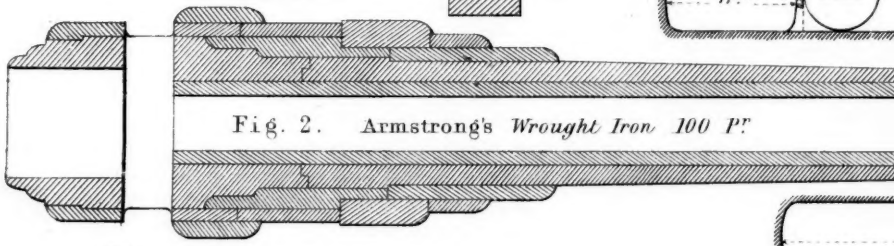


Fig. 2. Armstrong's *Wrought Iron 100 Pr.*

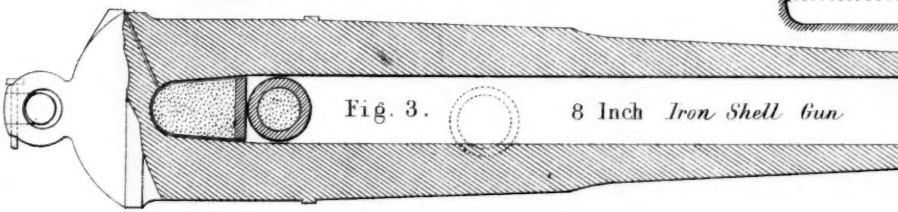


Fig. 3. 8 Inch *Iron Shell Gun*

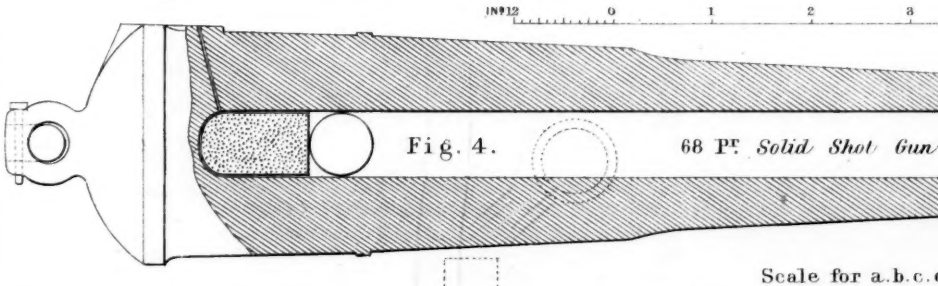



Fig. 4. 68 Pr. *Solid Shot Gun*

Scale for a.b.c.



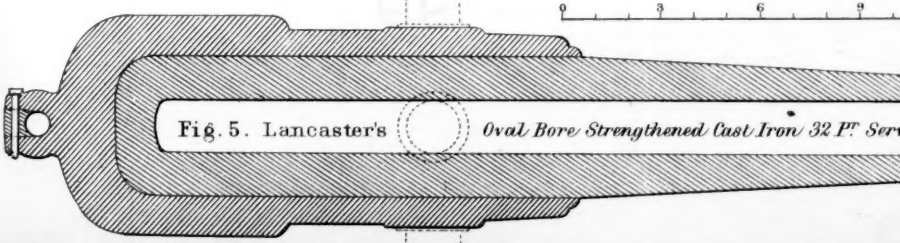



Fig. 5. Lancaster's *Oval Bore Strengthened Cast Iron 32 Pr. Serv*

g velocities of 300 and 600 Fds per second respectively.

300 400 500 600 YARDS

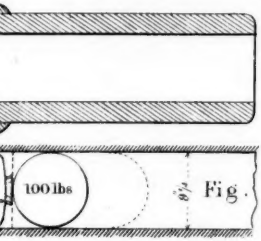



Fig. 11.

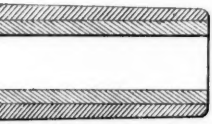
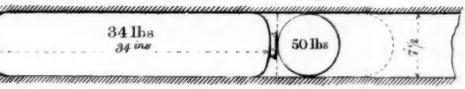
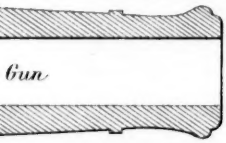
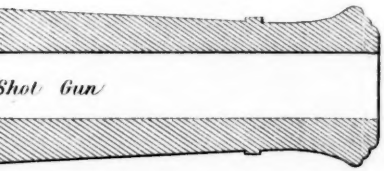


Fig. 12.



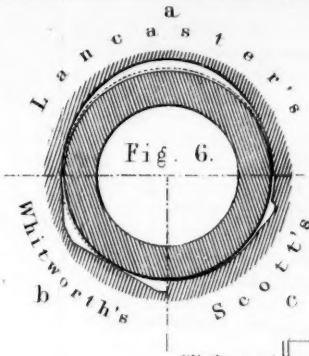



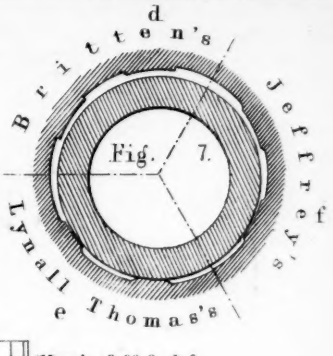

3 4 5 FEET




for a.b.c.d.e.f.g.h.i.

9 12 18 INS




Windage at Muzzle - 3.00 Sq. Ins

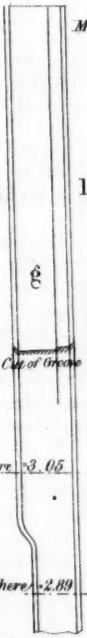



Fig 10

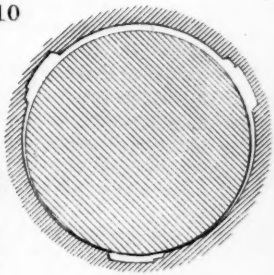
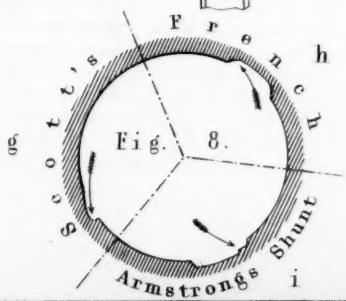


Fig. 9.




J.R.Jobbins

TABLE B.

OFFICIAL REPORT.—Velocities obtained by Capt. Andrew Noble, R.A., with Narvez's Ballistic Pendulum.

| Nature of Gun. | Powder. | Projectiles. | | | Velocity at 30 yards. | Initial Velocity. | Remarks. |
|---|---|---|---|---|---|---|---|
| | | Nature. | Weight. | Diameter. | | | |
| | lbs. oz. | | lbs. | Inches. | | | |
| 32-pr. rifled shunt, 59 cwt. ... | 5·8 | Plain shell. | 54 | 6·35 | 1215·7 | 1224·5 | Solid zinc bearings. —E.G.F. |
| 32-pr. 59 cwt., smooth | 5·8 | Cylinder. | 54 | 6·35 | 1187·4 | 1201·0 | |
| 12-pr. A. 6 cwt. | 1·6 | Plain shell. | 11·9 | 3·074 | 1103·4 | 1111·8 | |
| 12-pr. 6½ cwt. ... | 1·4 | Common shell. | 8·12 | 4·55 | 1124·2 | 1163·4 | |
| 12-pr. A. 8½ cwt. | 1·8 | Seg. shell | 11·9 | 3·084 | 1180·9 | 1190·2 | Experiments to ascertain the effect of diminishing lead on base of 12-pr. Armstrong projectile. |
| | 1·8 | — | 11·9 | 3·074 | 1238·3 | 1248·2* | |
| | 1.8 | — | 11·9 | 3·010 | 1200·0 | 1209·7† | |
| 68-pr. 95 cwt. ... | 16.0 | Round shot. | 66·4 | 7·91 | 1553·3 | 1579·0 | |
| | | | 51·8 | 7·91 | 1769·4 | 1809·9 | |
| 32-pr. 58 cwt. ... | 10·0 | Solid shot. | 31·6 | 6·17 | 1653·0 | 1690·0 | |
| 12-pr. 18 cwt. ... | 4·0 | — | 12·10½ | 4·52 | 1718·0 | 1769·8 | |

* Shell fired under normal circumstances.

† Same shell, lead reduced to the same diameter as the gun, except 0·25 of an inch at the base.

TABLE C.

| Description of Gun. | Point Blank Range. | Height of Platform. |
|---|---|---|
| | yards. | |
| 68-pounder, 95 cwt. (smooth bore) .. .. .. .. | 310 | 8 feet. |
| *68-pounder, 112 cwt. (ditto) | 400 | 8 feet. |
| 100-pounder Rifled Armstrong | 345 | 17 feet. |
| 13-inch Horsfall 280-pounder (smooth bore) .. .. | 600 | 20 feet. |

* Service charge of this gun is 20 pounds of powder.

TABLE F.

Royal Artillery Practice Cards.

| | ¼° | ½° | 1° | 2° | 5° |
|---|---|---|---|---|---|
| Brass 9-pounder, charge 12lbs. 8oz. ... ... | 400 | 500 | 700 | 1000 | — |
| Armstrong 12-pounder charge, 1 lb. 8oz. ... | 150 | 300 | 560 | 993 | — |
| | Fired from own field carriages. | | | | |
| Armstrong 12-pounder... | — | — | — | 1130 | 2146 |
| Whitworth 12-pounder... | — | — | — | 1198 | 2368 |

Fired 17ft. above plane.

Armstrong and Whitworth competition with service charges, powder ⅓th weight of projectile.

Whatever, therefore, may be determined on as to smooth-bore guns, round shot cannot be dispensed with, especially when the calibres are further increased, for elongated shot cannot be driven with equal velocity; their greater weight, and the friction on the lands, or wings, to give them rotatory motion, must always prevent their attaining very high velocities, nor can it with reason be said, that the charges with such shot can be increased to the amount used with the round shot, since the increased tension which that would entail would destroy any gun yet made, and likewise destroy many descriptions of rifle projectiles.

Table (B) of experiments is offered, in proof that there is no more friction in the shunt rifled gun than in the smooth bore, but that is simply impossible. The shunt rifled gun nips its missile as it passes out, for the purpose of obtaining greater accuracy, but if there is no greater friction there can be no nip and no directing power. It is but too palpable that there is a destructive amount of friction, and a retardation of the bullet near the muzzle of the bore, and from the shot being elongated, the powder is exploded under greater pressure, and a more elastic gas is generated, which, counterbalancing much of the force absorbed by the friction, may hide in part its existence from view. That the gas under such circumstances is more elastic, is proved "by the fact, of the back action increasing with the angle of elevation, and the initial velocity of round shot increasing with it *pari passu*."

The friction and consequent increase of tension prevents the powder charge from being increased in any of our present rifle guns, so as to obtain an effective initial velocity.

Had the powder been increased, the shunt shot would have stripped, or the gun itself would have yielded. But the fact is, the table does not supply data sufficient from which to form a correct estimate, and there is no parallelism between a cylinder with its large frictional surface, and a round shot, which rests upon a point and at once rolls in the bore.

And yet the experiment with the cylinder mentioned in Table B is

given as a proof that there is no friction in the rifled gun, overlooking two important elements wanting to constitute it a scientific experiment, viz., absence of equality of windage and of tension on the gun; the latter must always be the starting point, as that must determine the quantity of powder.

The argument that the smallness of the recoil of rifle guns, establishes that there is little friction, and therefore little tension on the gun, is a fallacy, for it is the intensity of the friction that prevents the gun from recoiling; so great is it, that it could not fail, with higher charges than those used for *them* now, in time to disintegrate such guns, by separating the chase from the breech, or more properly the inner cylinder from the outer; indeed, I believe this has already in many cases taken place.

The friction of some of the rifle projectiles has been estimated as absorbing nearly half the power of the powder burnt, all which goes directly to injure the gun.

The retardation of the shot, of which there can be no question, is an undeniable proof of the existence of the greater friction of rifle projectiles and of the increase of tension which it occasions to the guns.

The evil of retardation of the shot in ships' guns is so great, that it is a serious objection to any gun in which it occurs, as it becomes, from various causes common to ships, a very large element in inaccuracy—as, for instance, from the rolling motion, and the form of the decks, the effect of which would be similar to a jump from a violent recoil, or from the absence of a just preponderance, producing errors both in elevation and in direction, proportionate to the amount of the retardation.

Since I wrote the above, the following extract has been placed in my hands, in which are summed up the results of some experiments:—

"The 68-pounder was loaded and fired five times, *very good shots*, the distance being about 2,000 yards; while the 100-pounder Armstrong was loaded and fired three times, and, from some unaccountable reason, *very bad shots*, yet they were laid very well, so that in a seaway, or where at least the ship is rolling like the gun-boats do, 25° altogether, the 68-pounder pivot-gun beats the Armstrong 100-pounder completely. Such was the opinion of all who were there and saw the firing. I suppose on shore the Armstrong is best, but not at sea." The extract bears the impress of truth, and that the writer was not prejudiced, for he deems the result as unaccountable, while I, under the circumstances, consider that none other could reasonably have been expected. This leads us to the conclusion that, with care in the improvement of smooth-bore guns and their missiles, we may obtain sufficient range and greater accuracy afloat than with rifled guns, while the former would possess what the latter is so wanting in, viz. smashing effect at short ranges.

I take this view, though it may be said to be retrograde. It is not so, however; rifling evades the difficulty by making others, which at short ranges are very much greater; in fact it destroys effectiveness against iron plates. Now I only propose that the causes of the errors in round shot shall be directly removed. These are: an undue amount of windage, imperfect sphericity, and absence of homogeneity. The following tables show how much may be effected by a reduction of the windage. Table D shows the effect of the reduction of windage:—

TABLE D.

| Nature of Gun. | Length. | Weight of Powder. | Windage. | Elevation. | | |
|---|---|---|---|---|---|---|
| | | | | 1°. | 2°. | 5°. |
| | ft. in. | lbs. | parts of inches. | yards. | | |
| *32-pounder, 56 cwt. .. | 9 6 | 10 | ·233 | 700 | 1130 | 1964 |
| 32-pounder, 40 cwt. .. | 8 0 | 6 | ·175 | ‡731 | — | — |
| 32-pounder „ | „ | „ | ·175 | 715§ | — | — |
| 56-pounder, Monk, 97cwt. | 11 0 | 16 | ·175 | †930 | 1340 | 2200 |
| ‖110-pounder Armstrong | — | 12 | Nil. | 530 | 920 | 1970 |

* From Aide Memoire to the Military Sciences.
† Handbook for Field Service
‡ Height above plane 15 feet.
§ „ „ „ 8 „
‖ From Royal Naval Official Ranges.

Table C *a* (Appendix) shows the range at first grazes at point blank, it shows also the comparative initial velocities.

Table E, showing results obtained in America, appears to demonstrate that the windage of smooth-bore shot might be reduced still more, with satisfactory results as to accuracy, increase of initial velocity, and, therefore, of smashing effect, without, from a certain point, increase of tension on the gun; and, as the injury from lodgements arises from large windage, its reduction would increase the lives of guns.

This table establishes in a striking manner that the friction of, and tension on, these rifled guns must be very great, or the initial velocity of their shot would be very much greater; ·170, which is less windage than that of the smooth-bores in the naval service, gives a range of only 52 yards as compared with 288 with only ·025 windage.

TABLE E.

AMERICAN EXPERIMENTS.

From Simpson's "Ordnance and Naval Gunnery," used as a text-book in the U.S. Navy.

| Kind of Powder. | Range in Yards. | Pressure on Plug. | Pressure per square inch in lbs. | Diameter of Ball. | Windage. |
|---|---|---|---|---|---|
| | | lbs. | | inches. | parts of in. |
| Dupont, 30 ... | 288 | 301 | 1·179 | 5·63 | ·025 |
| | 92 | 331 | 1·297 | 5·535 | ·120 |
| | 52 | 207 | 811 | 5·485 | ·170 |

Tables C and C *a* (Appendix) show ranges and particulars of Horsfall's 280-pounder; this Table shows the point-blank range as compared with those of the Service 68-pounders and Armstrong 110-pounder. The 68 appears to a disadvantage; its range was taken at a height of only 8 ft., the other two, Sir William Armstrong's at 17 ft, and Horsfall's at 20 feet. This would make a considerable difference in their range against that of the 68-pounder. The time of flight of Horsfall's smooth-bore is about half that of the other, and shows abundantly, to what perfection smooth-bore guns may be brought. The windage in the 68-pounder is ·198, that in Horsfall's is only ·08, the effect of which may be gathered from the American results.

In the field it is admitted that the difficulty of judging distances, and other disturbing circumstances, are such, as to confine the ranges of projectiles for military purposes to 2,000 yards; afloat, the disturbing causes, *which are constant*, are greater, from which the various movements in rifle sights become causes of error, therefore the most useful ranges cannot be greater than those obtained by Mr. Horsfall's gun at little above point blank, and with powder only one-sixth the weight of shot, while the elevation of rifle guns is considerable for the same distances. Then, as the angles of descent are great, the chances of striking an object are scarcely worth the powder used. The smashing effect of this gun would be three times that of the 150-pounder.

The former conclusion Sir H. Douglas arrived at *some time* since, for he says,—"The main principle which should govern our choice of naval guns is, to prefer those which with equal calibre possess the greatest point-blank range." This was the correct view to have taken before the introduction of iron-coated ships; since that, we have no choice, as no other guns will be completely effective against iron plates, if against other ships either.

Imperfect sphericity, another cause of error in round-shot, may be removed in working scrap-iron into wrought-iron shot, made requisite by the introduction of iron-plated ships; a nearer approach to homogeneity will at the same time be made, while the expense of such, will still be far below the cost of any of the elongated shot.

Since this paper was written I have seen a pamphlet on this subject, in which the value of smooth-bore guns and improved shot are set forth. It is by Mr. M. Scott, C.E., and shows the turn which the public mind is taking.

To the extent that we have adopted rifle guns, to the exclusion of smooth-bores, for the navy, we have given up the substantial advantages of low trajectories, straight ricochet, smashing force, simplicity, and economy, for the very occasional advantages of long range. Therefore, for efficiency, no less than for economy, we must revert to the smooth-bore in principle, and invest talent and money to develope its merits.

But rifle guns and elongated shells, especially of small and medium calibre, have decided advantages, because of the greater quantity of powder these shells are capable of containing, and long range is also sometimes very important for the support of troops and for breaching purposes; we should therefore endeavour, if possible, to combine the advantages of the round-shot with those of the elongated, in one description of gun; but even for the simplicity which this would bring with it, no sacrifice of initial

velocity is admissible. So that, unless a mode of rifling can be found, that will not involve undue windage, we must have both descriptions of gun, in numbers proportionate to the relative importance of each: little windage, then, must be the ruling qualification in the selection. Such is that proposed by Captain Scott, R.N., such is that used by the French in their rifled gun that admits of the use of round balls. It should be a muzzle-loader, simple of construction, strong, and as little liable to get out of order as possible; for neither ships nor fleets can take factories to seawith them.

This would exclude all multigrooves, or those with a sharp-edged rifling, which would be destroyed by the passage of round shot over the lands.

Breech-loaders would also be excluded, for they would be too weak in the breech to stand the high charges necessary, and they are dangerous; their greater weakness will be seen by a glance at Plate I. fig. 2, which represents the Armstrong breech-loader, in contrast with Plate I. fig. 1, which represents a 200-pounder gun of Captain Blakely. Thus, in fig. 2, the entering the cartridge, &c. from behind, entails a bad form of chamber; the squareness of the end of which, in Sir William Armstrong's gun, is a proved cause of weakness, as is evident from a comparison of that shown in fig. 3, which is a form known to add to the endurance of the gun. The holes for breech-screw and breech-piece further greatly impair its strength; indeed it seems impossible, with so many parts subject to the action of highly elastic gases, that a gun thus constructed, could be otherwise than weak, and extremely liable to injury.

The coils are shrunk on hot; the metal, of course, contracts in every direction, consequently the joints open; it were impossible they should be close; the *overlapping* pieces at the joints indicate the knowledge of this defect. All these are points of weakness, and the whole of the great vibration which takes place every time the gun is fired must be thrown in turn on these separate parts, and not distributed, owing to the continuity being broken, which must lead early to the disintegration of the gun.

The maximum initial velocity being of necessity the primary consideration, when the smallest increments of time involve the whole question of hitting or not, and always diminish the chance of doing so, lead-coated shot cannot be safely used, nor those either where lead is expanded or compressed into grooves, for the charges required to give high velocities, would certainly force these missiles through the gun without their taking the rifling, causing them to strip; and to use hardened lead on the compression principle with high charges, would inevitably prove fatal to the piece; the liability of leaden missiles to become out of shape by falls would, when it occurred, as is too probable on board ship, increase much the difficulty of loading from the muzzle, and also the danger of bursting the gun.

High charges also would crush up compound shell, and damage the bore near the chamber even more than is the case now, which is so much so in the expanding rifle projectiles, that the grooving at the seat of the projectile is after a time obliterated. The uncertainty and danger of these is such that it becomes a question whether, even for special though unfrequent service, they should be used on board ship.

It has been set forth as a merit that such guns are economical because of the small quantity of powder required for them, covering up the fact, that the sum saved in powder is more than doubled in the cost of the shot.

APPROXIMATE PRICES OF ARMSTRONG AND SMOOTH-BORE SHOT.

| | Description of Gun. | Charge. | Cost of Shot. | Cost of Powder. | Total. |
|---|---|---|---|---|---|
| | | lbs. | *s.* *d.* | *s.* *d.* | *s.* *d.* |
| Armstrong . . . . . | 110 | 14 | 17 0 | 9 4 | 26 4 |
| Smooth Bore . . . . . | 68 | 16 | 3 0 | 10 8 | 13 8 |
| Armstrong . . . . . | 40 | 5 | 8 0 | 3 4 | 11 4 |
| Smooth Bore . . . . . | 32 | 10 | 1 5 | 6 8 | 8 1 |

It cannot be economy to sacrifice efficiency, and such guns are valueless against iron plates.

The Whitworth gun, though giving satisfactory results with long ranges, under circumstances seldom or never occurring on board ship, is still open to many serious objections.

The angles of its missile in the process of rotation, press against the inner surface of the gun, and cut into it, tending to rip it up.

Lastly, it is unsuitable for round shot, as the angles, as may be observed from Fig. 6 *b*, would necessarily entail a great loss of power by the escape of gas; the shot also would be proportionately small for the same reason.

The Lancaster oval, Fig. 6 *a*, would be very dangerous with large charges, and it also is unsuitable for round shot; the loss of power by the escape of gas would be very great, but a more serious objection is, that the use of round shot and high charges would destroy the gun very shortly.

Without enumerating all the rifle guns, it appears to me that the claim to superiority lies with the three-grooved guns, the others being thrown out, by the large portion of the bore that is cut away by many grooves, or by wide grooves, entailing weakness and undue windage.

Figures 6 and 7 represent sections of different rifle guns drawn to scale; a round ball is placed in the bore, and show the amount of windage that the use of such, would entail in each kind respectively, very large in Lancaster's and Whitworth's, and least in that of Captain Scott. Captain Blakely has abandoned his, and has adopted that of Captain Scott in the guns he has made for foreign governments. Plate II. fig. 18, shews the effect even more distinctly. Suppose the rectangle *a* to represent the whole of the inner circle of the cylinder of the gun, then the smaller rectangles *b*, *c*, *d*, *e*, *f*, *g*, *h*, represent the quantities of this circle required to be left untouched in rifling, according to the respective plans named.

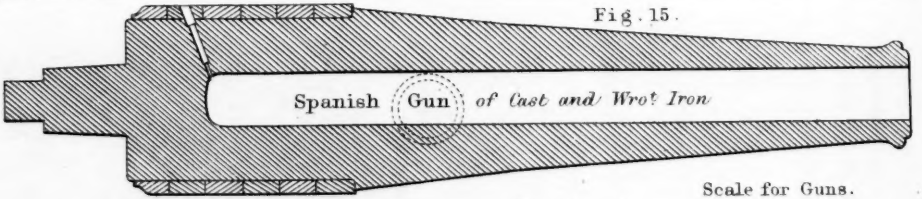
The total amount of windage occasioned by the different systems of rifling, when the present round shot are fired, is given in table H.

Fig. 18.

*Comparative Surfaces of Original Bore untouched by Rifling.*

| | | |
|---|---|---|
| 1·000 | Original Bore. | a |
| ·855 | Scott's | b |
| ·763 | Armstrong's Shunt | c |
| ·500 | Blakely's | d |
| ·433 | Jeffrey's | e |
| ·388 | Lynall Thomas's | f |
| ·169 | Whitworth's | g |
| ·010 | Lancaster's | h |

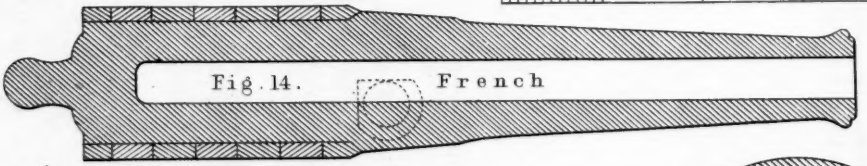
Fig. 15.




Scale for Guns.

12 6 0 1 2 3 FEET

Fig. 14.




Scale for j. k. l.

0 3 6 9 12 INCHES

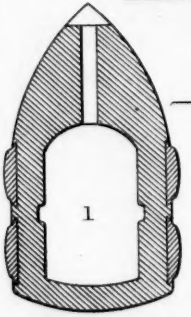
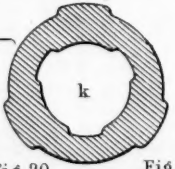



Fig. 17.

*Sections of Shell used in Spanish Gun.*




*Transverse Section of Spanish Gun*

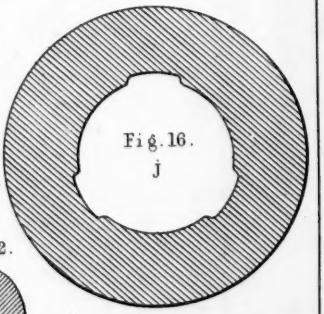



Fig. 19.

*Plain.*

Fig. 20.

*Molten Iron.*

Fig. 21.

*Segmental.*

Fig. 22.

*Solid Shot.*

J.R.Johbins.

TABLE H.

| | |
|---|---|
| Diameter of bore ... ... ... ... ... ... ... ... ... | 6·375 |
| Diameter of round shot .. ... ... ... ... ... ... ... | 6·177 |
| Windage ... .. ... ... ... ... ... ... ... ... | ·198 |

| | Area of Bore. | Area of Round Shot. | Area of Windage. |
|---|---|---|---|
| Original bore ... ... ... | 31·92 | 29·97 | 1·95 |
| Scott's ... ... ... ... | 32·24 | ,, | 2·27 |
| Britten's .. ... ... ... | 32·55 | ,, | 2·58 |
| Armstrong's shunt ... ... | 32·97 | ,, | 3.00 |
| Jeffrey's ... ... ... ... | 33·07 | ,, | 3·10 |
| Lynall Thomas's ... ... | 33·34 | ,, | 3·37 |
| Whitworth's ... ... ... | 34·62 | ,, | 4·65 |
| Lancaster's ... ... ... | 34·73 | ,, | 4·76 |

**The above results have been obtained by measurements from the guns.**

There are three guns with three grooves—the Shunt, by Sir William Armstrong; * the French gun; and that of Captain Scott, of the Navy. (Plate I. fig. 8.)

In the shunt gun the grooves are double, with sharp edges (Plate I. fig. 9); the rotatory motion of the shot is produced by zinc ribs, which run in the grooves—slack going in, to facilitate loading, tight coming out. For greater accuracy, the rifling diminishes in diameter towards the muzzle, to nip the ribs (fig. 10); this necessarily increases the tension on the gun, to which it must prematurely yield; also, there cannot fail to be uncertainty from unequal yielding of the zinc, and a great danger that, with high charges, the ribs would strip off. The missiles would be delicate for the rough usuage of ship service, and the feeling that shot might strip would have a very bad moral effect. The bearing side of the groove of the French gun (see fig. 8 *h*) is not unlike that of Captain Scott's (fig. 8 *g*); the preference is due, however, to the latter, as the direction of the friction is less injurious to the gun.

Again, the rotatory motion of the French missile is produced by studs of soft metal, which are liable to injury, and would certainly fail under the pressure of high charges, and when bent, are liable to burst the gun.

* *Sir William Armstrong.*—You have no correct section of the shunt principle there?
*Captain Fishbourne.*—Mr. Vavasour kindly measured all the guns, and drew them for me. He will establish the correctness of his measurements.
*Sir William Armstrong.*—He cannot: there are no measurements given.
*Captain Fishbourne.*—The measurements are given in table H.
*Sir William Armstrong.*—Then in the diagrams you are showing, there is a far larger space in the grooves than actually exists.

The rotation of Captain Scott's shot is obtained by ribs cast on the shot; they are simple, strong, little liable to injury, and cannot fail; better to steady and direct the shot, and give greater accuracy than studs. The edges of these ribs are softened off by a coating of zinc, giving them any advantage that may belong to soft metal, without the disadvantage.

*g* fig. 8, represents the shoulder of Captain Scott's; the friction, which is in the direction of the circle, bears against it, whereas, owing to the nipping of the shunt, the pressure is directly outwards, tending to burst the gun, *i* fig. 8. If there is no friction, there is no directing power.

No doubt round shot might be fired from these three guns, as also that of Mr. B. Britten, and, indeed, others; but the loss from windage through the many or deep grooves would prevent round shot attaining a sufficiently high velocity. The many grooves and the wide grooves, impair the strength of the gun, while the narrow lands would soon be eaten through by the friction (*d*, *e*, *f*, fig. 7).

Nor can the evil be remedied, for with increase of powder the grooves must be deepened, or the soft metal will strip or ride over the lands without taking the rifling. By the system proposed by Captain Scott of having strong iron wings, as it were lubricated by a soft metal, great initial velocity for a rifle may be obtained; the mode of rifling being least injurious to the strength of the gun. His missile being also the strongest, simplest, cheapest, and least liable to injury, possesses the strongest claim to be adopted as the naval pattern for a rifle gun.

I might have gone into many details interesting and important in their degree, but *un*important till the question of principle was decided. To that I have endeavoured to confine myself, and I feel sure the discussion were better thus confined. I have satisfied myself, and can only wish I may have satisfied my audience, that with round shot (perhaps it may be with smooth-bore guns) alone shall we be able easily, safely, and economically to obtain that velocity of flight over short ranges, that shall be effective against iron-plated ships; and that the long-range guns are of more limited value for military purposes generally than has of late been supposed; and, as they are of still less value for naval purposes, it will be matter of grave surprise that so much has been spent in producing guns so deficient in the prime qualifications for good naval guns—viz., 1st. Great initial velocity—no great part of which must be sacrificed to the rifling. 2ndly. Simplicity of construction in gun and in all its appointments. 3rdly. Muzzle-loading, for safety with high charges. 4thly. Mode of rifling to be strong, simple, and least injurious to the gun, or easily injured by round shot, or by any other cause, such as leading, constantly in operation. 5thly. Missiles to be simple, strong, and least liable to injury.

It is due to Captain Scott to say that thirteen months since he strongly insisted in this place on the value of rifled guns that would admit of the use of round shot, and that every experiment in that direction establishes more and more the correctness of the views he then stated. The *Times* in a recent number gives 3 and 3½ inches as the penetration of a 68-pounder with 20 and 24 lbs. of powder, the probability is that the windage of that guns was ·198—far too great; that of Horsfall's gun is only ·080; ·060 would be sufficient; a reduction to half ·198 would produce nearly, if not quite double the effect reported. The cast-iron guns in their present

condition would hardly stand the high tension, but hooping them would be a rapid, effective, and economical way of using up our present stores, and of obtaining an early supply of guns; the propriety of ordering more cast-iron guns is doubtful.

A question here arises as to the construction of the guns: we have seen what danger and weakness arose from violating the law of homogeneity in the breech-loaders; this may not be repeated without grave responsibility, and as we must have high charges at all costs, with increased tension, it seems the undue application of the coil system as in use, will have to be modified, if not abandoned, for forging in whole, or to a greater extent; the forged guns would stand the blow of a shot vastly better than a coil gun. And therefore it is an important consideration as to whether it is worth paying 650*l.*, the price of a 110-pounder, for what at 300*l.* or 350*l.* would suit our purpose equally well on most points, and better on this important one.

As a practical illustration of how the two systems of coils and forging might be combined with advantage I may suggest the following, the result of conversation with practical men:—

The internal tube reaching to the muzzle should be forged in one piece, closed at the breech, of iron approaching to the character of steel, and wrought on a mandrel, hollow; breech-piece, including the trunnions, should then be brought over; lastly, over the chamber there should be a coil, to give more tensile strength to resist the effect of explosion.

The question is one of great national importance, both in an effective, an economic, and commercial point of view, so great as to justify us in calling on those gentlemen who have displayed so much talent in working out their respective plans, to look at the question less from a personal and more from a national point of view, and agree to differ as to the respective merits of their respective plans, and, while differing, agree to join in producing the gun best suited to serve their country's interests.

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The Duke of SOMERSET: Gentlemen, I am sure you will all agree with me that at any rate this is a most important question to be considered, and that we ought to be greatly obliged to the gentleman who has opened this discussion for us. Now that it has been opened, I hope the discussion will be carried on by those who have considered the subject fairly and calmly. For myself I would say this, that I have read a great deal and heard a great deal about guns of all kinds. Of what I have heard there is a great deal I do not believe, and very little that I do believe. What we want is to get some progress. I have not yet heard distinctly whether you intend entirely to give up the cast-iron gun, or whether you take entirely to the wrought-iron gun. Whether you object to the rifled or the spherical ball bore is another question; but I should like to hear from those who have considered the subject some little progress. I believe we shall get that progress best by just calmly talking over the matter.

Vice-Adm. the Honourable Sir FREDERICK GREY, K.C.B.: As Sir William Armstrong is here, perhaps he would have the kindness to explain to us some of the points connected with his gun that have been objected to, and that would, perhaps, open the discussion in the most satisfactory way.

Sir WILLIAM ARMSTRONG: The paper which has just been read, embraces such a large number of facts which I feel myself called upon to answer, that I really do not feel able, on the spur of the moment, to go into a complete refutation. There can be no doubt but that this question will have to be adjourned; and it would certainly be more satisfactory to myself, and probably in its results more satisfactory to the meeting, if you would allow me to take a little time to consider the subject. I should be prepared the first thing to-morrow night to give a general statement, not only in refu-

tation of what has been advanced, but also as conveying my own views as to what is proper to be done in regard to naval armaments under the present aspect of the question.

Major-General ANSTRUTHER, C.B. said, the recorded range at ten degrees of elevation of Sir William Armstrong's gun, speaking from memory, was 3,598 yards, and the longest range ever known to be got by a round shot was 3,130 yards. With one-eighth of the shot's weight, Sir William Armstrong's gun got more initial velocity, because it got more range, at the same elevation than the round shot ever attained. (No, no.) He was prepared to maintain it against all comers.

Colonel WILFORD, R.A.; I will explain in a few words why the initial velocity of round shot is greater than that of the Amstrong shot. In the first place it has been determined by the galvanic apparatus at Shoeburyness that the 68-pounder, as a matter of fact, has greater initial velocity than the Armstrong. Now for the reason why. Suppose we take two projectiles of equal diameter, one spherical, the other elongated; the transverse section, or that perpendicular to the trajectory, will be equal in each case; therefore the column of air to be displaced will be equal in each case; and hence the resistance will be the same. But, the elongated projectile overcoming the same resistance of air, has much greater weight behind it to overcome that resistance. Hence it is, that, although a spherical projectile of equal diameter may have a much higher initial velocity at the muzzle than the elongated, yet, suffering a much greater retardation, its velocity is much more rapidly diminished; therefore, in the latter part of its flight it passes more slowly over the ground; hence it does not go the same distance at the same elevation as the elongated, which, although starting at less velocity, preserves it more uniformly throughout its flight.

General ANSTRUTHER was much obliged for the answer. It was the first time he had been able to get an answer. But as the initial velocity was not the subject of discussion, he should not go into it now, except to say that he differed *in toto* from all that Colonel Wilford had stated. To return to the point under discussion, Ought not all these experiments in guns to be tried in brass, because, if condemned, they could be re-melted? Why was it that everybody used the most expensive metal, and hammered out 900 guns, only to find that there was a better gun which could be made? The objection against brass guns was, that they drooped at the muzzle. Now, the drooping at the muzzle was owing to the very injudicious plan of placing the trunnions. Were the trunnions placed close up to the muzzle astragal, there could be no drooping.

General Anstruther here produced the model of a modification of the Prussian breech-loader, which he described, and declared to be the simplest and speediest loading gun in the world.

Colonel WILFORD: I should like to explain why brass cannot be used. In artillery you cannot safely proceed from small things to great, as you can in many other things. A thing that answers perfectly on a small scale in a model, fails on the large scale. Now, I proceed to show in a very few words why an experiment with a small brass gun would be worth nothing as applied to a large gun. Many years ago iron mortars were introduced into the service, and why? Because, when large brass mortars were used, holes were burnt in the chamber owing to the immense heat generated by a large charge of powder acting on the material of the gun metal. The results of the experiments can be seen in Sir William Armstrong's department at Woolwich as conducted by General Sir Thomas Blomfield, formerly Inspector of Artillery. Therefore, if you are to make these experiments on a large scale in brass guns, the heat generated would be so great that the form of the gun would very soon be changed, and your experiment would be comparatively valueless.

Lieutenant-Colonel CLAY, 8th Lancashire Artillery Volunteers: Although I am myself unprepared to speak upon a subject of so much importance, still, having had some slight experience in the manufacture of guns of large calibre, I may perhaps be permitted to make a few remarks, which will be short and to the purpose. I think, in the first place, it will be very desirable that each gentleman who addresses the meeting should endeavour, as far as possible, to avoid treading upon his neighbours' toes, and confine himself to bringing before the meeting any merit which he considers may apply to his own invention or to the particular article in which he is more immediatedly interested. In the year 1856, during the Russian war, when accounts appeared in the public papers that it was desirable large ordnance should be made, a gun was attempted to be manufactured somewhere in Lancashire by an eminent engineer, that gun failed, and it was stated in the public prints that the reason of the failure was, that, on account of the long continued heat of the mass of metal, the iron was carbonised to such a

degree, that, even if the gun had been made, it would have been weaker than cast iron. We felt that our reputation as iron-masters, making the largest description of forging, was somewhat at stake, and we resolved at once to offer to make and present to Her Majesty's Government a gun as large as, or larger than, the one attempted to be made. The reason of that was, that when so eminent an engineer had attempted to manufacture a gun, and failed, we thought, our name not then being so well known to the public as it is now, that Government would not have been justified in making another grant of public money for us to make a similar attempt; therefore, the only means by which we could get the Government to try the gun, was by offering it to them in such a way, free of cost, that it could not be refused. The gun was made, and was proved on the shore at Liverpool by Major Vandeleur, Instructor of Artillery, who was sent down expressly for that purpose. It was proved with 45 pounds of powder, and with shell loaded with lead, weighing 310 and 318 pounds. This was then thought such an enormous charge for artillery, that the then Select Committee sent charges to Liverpool weighing from 10 to 24 pounds, with instructions that we were to begin with the smaller charges, and, if the gun did not burst, we might proceed to the larger ones. In the absence of the Artillery Instructor, Sir Duncan Macdougal, in command of the Lancashire Artillery, then at Liverpool, placed a gun detachment at our disposal. We began with 10-pound charges, and went on to the 20 and 30-pound charges. When the Artillery Instructor arrived, we had reached the 30 pound charge. He expressed his surprise, and told us it was useless to go on any longer with smaller charges. An experiment was also made, perhaps the first ever made, at the request of the Instructor of Artillery, against a battery-plate of 4½ inches thick. A target was hastily constructed on the shore, steadied with nine baulks of timber about 14 inches square, and firmly imbedded in a bank of sand, which solidified the whole structure. That battery-plate was probably masked in a manner that has never been equalled since. This was in the year 1856. Table C*a* (Appendix) shows the comparative ranges of the 68-pounder 95 cwt. service gun, and the 100-pounder rifled Armstrong gun, and the 13-inch Horsfall gun, at point-blank range. Each division of this table represents 10 yards. While the 68-pounder ranged 310 yards and the Armstrong ranged 345 yards, the 13-inch gun ranged 600 yards. The data with respect to the 68-pounder and the 100-pounder are taken from the "Handbook for Field Service," published this year. The data of the 13-inch gun is from the report supplied by Colonel Mitchell to the War Office, a copy of which the War Office has favoured us with. It has been remarked, and the remark is a very just one, that the circumstances are not entirely parallel in these three cases—that the 68-pounder gun was fired from a height of 8 feet above the plane, that the Armstrong gun was fired from a height of 17 feet above the plane, and that the 13-inch gun was fired from a height of 20 feet above the plane. This ought certainly to be taken into consideration; but, if we make a deduction from the range of these, to correspond with the height of the plane of the Armstrong gun, we shall have to knock off 90 yards in the range, which will give us a range of 510 instead of 600 for the 13-inch gun as against the 345 yards of the Armstrong gun. I have not made the comparison with the 68-pounder smooth-bore service gun, because after all the 13-inch monster gun is only an exaggerated 68-pounder. The ranges were not merely confined to point-blank range, but up to 10 degrees of elevation, the same guns being taken in the comparison. Up to 10 degrees of elevation we start with a slight advantage over the two other guns; at 12 degrees the Armstrong gun takes the lead, and, as everybody knows who has at all studied these matters, increasingly so, at still higher degrees of elevation. A remark was made just now that no smooth-bore gun ever got a range beyond 3,600 yards; that is simply ridiculous, because this monster gun has had a range of 5,009 yards.

General ANSTRUTHER: At ten degrees.

Lieutenant-Colonel CLAY: Not at ten degrees?

General ANSTRUTHER: That is the statement.

Lieutenant-Colonel CLAY: At ten degrees the range is 3,540.

General ANSTRUTHER: Which is 50 yards less still than the Armstrong, and it is not a smooth bore.

Lieutenant-Colonel CLAY: I can only give the data as I take it from the "Handbook of Field Service," and from Colonel Mitchell's "Report," and I consider, with the explanation about the difference in the height of the plane, we must take them as authentic. With regard to the charges of powder, the charge with the 68-pounder service gun is 16 pounds; with the Armstrong 100-pounder the charge is 12 pounds; and with the Horsfall gun the charge has been 50 pounds. Ninety rounds had been fired out of

that gun with 50 pounds of powder each. The proportion of the charge of powder to the weight of shot, was, in this case, one-sixth. Before manufacturing the gun, reference was made to the late eminent Sir Howard Douglas; I made a journey to France purposely to consult with Sir Howard Douglas. Before we commenced the manufacture of that monster gun in 1856, Sir Howard Douglas's remark, which I have never forgotten, was to the effect, "Give me a gun that will range at point-blank and I do not care anything for any long-range gun, or for any particular benefits that may result from it." He admired and wished to have the most powerful point-blank gun. I may perhaps mention incidentally, with regard to that gun, that I suppose no gun has ever had more powder and shot blown out of it. The recorded experiments, taking the quantity of powder for charges from 10 pounds up to 80 pounds, show that there have been upwards of 7,000 pounds of powder and 60,000 pounds of shot blown out of that gun, and, if a slight defect has shown itself, I should like to be informed where the other gun is, that has blown out anything like the same amount of powder without showing any defect. I am happy to say that at last, after many years' endeavours, we are about to get some measure of justice to that gun. Lord Ripon at the War Office to-day promised that it should be immediately tried, and in its present condition. In visiting it a few days ago at some gun experiments at Portsmouth, I was sorry to find it nearly buried in the shingle, and so rusted was it, that I hardly knew my own child. I find that the officers who proved it, and even the very gunners, who are there still, informed me, although they had no knowledge of who I was, that they have the most unbounded confidence in the gun and I fearlessly challenge the whole country, when I say that that gun as a battery gun is unequalled, and has had more effect than any other gun that has ever yet been made.

While upon this subject, I may, perhaps, say a few words about the forging of guns and building them up. At several meetings such as this held in London, I have almost alone stood up for the plan of making guns in one piece of wrought iron, and I am glad to find at last, that the opinions of many gentlemen who have studied this question are somewhat modified, and coming round to that view of the subject. Whether solid-made guns or built-up guns are the stronger, I care not to inquire into; all I care about is, that the guns I advocate, solid-made wrought-iron guns, are amply sufficient for every useful purpose, and at the same time I believe they can be made at a very much less cost than any built-up guns, with the exception perhaps of guns the principal portion of which is cast-iron, and strengthened by wrought-iron or steel hoops. That is a question which I wish not to enter into, but I would merely guard myself by saying that I do not mean to say that solid wrought-iron guns can be made cheaper than those guns. The question will probably be entered into by the various gentlemen whom I see round me, in dealing with the merits or demerits of cast-iron for ordnance purposes. With regard to the size of the gun, it seems now to be an important question as to what size a gun can be made safely or economically, with the view of being placed in our forts, or, if possible, be carried by our ships. In 1856, the monster gun, weighing 21 tons 17 cwt. was pooh-poohed as a gun too large for any useful purpose whatever, yet I may take this opportunity of observing, that the proportions of which I intended to make that gun were considerably increased by the authorities at Woolwich. Now, there seems to be an opinion that, at any rate in fortifications, guns, if they are effective, can be used of any size that it is possible to make them. I do not know whether I am out of order. I am not much accustomed to be examined by Committees, but upon my examination by the Defence Committee, a few days ago, I had some questions asked me there. Perhaps my Lord Duke would inform me whether I am permitted to make known to the meeting what was said upon that occasion.

The Duke of SOMERSET: I do not think there will be any danger in your stating it to the assembly.

Lieut.-Col. CLAY: I was not aware whether it might be considered private and confidenial. I was asked whether I could undertake to manufacture a gun which would penetrate the sides of the *Warrior* at 1,000 yards. I stated that I should have no hesitation, with our present machinery, to undertake to manufacture a gun that would, in my firm belief, fracture the side of a ship constructed as the *Warrior*, covered with four-and-a-half-inch plates, at 1,000 yards. I was then asked the question whether I would undertake to do it at 2,000 yards. The question became a very different one, and involved so much difficulty that I declined to give any answer upon that subject; but it was there stated, that, if guns could be constructed, it would be desirable to construct them of such a size as to enable them to make a serious impression upon vessels

such as the *Warrior* at 1,000 yards. I believe there would be no difficulty whatever in making them, although the monster gun weighs 21 tons. I have no hesitation in saying, that, with our improved machinery, guns very much larger could be made with equal facility. I should like to say a few words about the method of making guns, as exemplified in the Prince Alfred gun, That gun was forged hollow. In the monster gun, at the end of the breech, as is generally the case when contraction sets in with either cast or wrought iron work of unequal dimensions, a small drawing or shrinkage took place in the bore of the gun. That is in consequence of the gun shrinking unequally; the cooling of the gun from the outside formed a solid arch, and the interior, in consequence of its weakness, gave way. We were not then in possession of so much experience as we have now, about the strength of the breeches of a gun, or that guns could be made upon this principle where a considerable proportion of the breech might be cut away with safety. Therefore, the bore was somewhat shortened, and a piece which we call the plug-piece was placed in the breech at the bottom, leaving most ample strength behind. It was simply to prevent the *débris* from the combustion of the gunpowder getting into the crack and causing the ignition of the next charge when there came to be rapid firing. That was got rid of by the plug. I am informed by the officers and men who conducted the last experiment, when the gun was proved with 80 pounds of powder, impressions being taken before and after two explosions, that no perceptible difference took place in that so-called flaw, and I was informed that the flaw was in the plug, a separate piece that was put in. And, as to the efficiency of the gun as a battery gun, I am informed that there is such confidence among the officers and men who have tried it, that they have no hesitation whatever in carrying on further experiments with it.

A gentleman asked if this Horsfall Gun was cast solid.

Lieut.-Colonel CLAY: It was forged solid and bored.

Colonel LEFROY, R.A., F.R.S.: At this late hour of the evening, I will not detain the meeting more than a few minutes. I have heard from my friend Captain Fishbourne several statements which I think extremely erroneous, and several arguments which appear to me extremely fallacious. In the first place, I wish to set at rest one doubt that has been expressed, in extremely strong language, by Captain Fishbourne, as to the possibility of giving a high initial velocity to a rifle-shot. I am in a position to state that an initial velocity of 1746 feet per second has been given to a rifled shot, with a charge of one-fourth the weight, with an Armstrong gun. On the same principle, we may reasonably conclude that an equally high initial velocity may be given to any other Armstrong gun with one-fourth the charge, the velocities with the service charge being nearly the same. I am far from saying that those guns will continue to stand being fired, an indefinite number of times with that charge. At all events, they can be fired a short time, because it is the habitual proof-charge of the Armstrong gun, and many of them have stood a great many proof rounds. Therefore there can be no doubt about that; there is no doubt they will stand to a considerable extent. I can also set at rest another question, namely, that it is impossible for lead-coated shot, forced through the bore with that velocity, to take the rifling. I reply, in point of fact, they do take the rifling, as can be seen any day at Woolwich, where they are fired with that one-fourth. Again, it is said that the less friction there is in the gun the greater the velocity. Now, we have guns of different lengths, and we find that when we shorten the gun we lose velocity very materially; that is to say, whatever it lost in friction, is more than made up by the time which is given to the powder to exert its entire force. It is a well-known principle in rifling, and I am surprised to hear it questioned at this time of day. Again, a comparison has been drawn between the point-blank ranges of a great variety of shot, fired at different heights above the plane. These point-blank ranges mean the distance from the muzzle to the point where the shot first strikes the sands below. Such a comparison is surely fallacious. The only true scientific comparison of point-blank range is the distance from the muzzle of the gun to the second intersection of the trajectory with the line of the sight. And, when we come to consider what are the real angles at which these shot are fired, it is sufficient to account for the difference of point-blank range. For example:—a shot fired horizontally by spirit levels from a platform seventeen feet high will range say 400 yards, but this shot is really attributable to an angle of three-quarters of a degree. But, when we come to discuss these things with scientific precision, we must be careful to eliminate all the sources of variation, and to reduce them to their proper value. Again, a comparison has been drawn between the 68-pounder shot with

its present initial velocity and what the initial velocity would be, were the windage reduced. Every officer knows we cannot reduce the windage of our guns; we should burst them if we did. Sir Howard Douglas drew attention to the subject in 1818, and no great reduction has been made since. If we do reduce it, we must reduce the charge of the guns. To account for the great difference of range between the late smooth-bore wrought-iron gun, it is sufficient to know, that, whereas the area of the bore through which the gas is able to escape in the 68-pounder gun is one-twentieth of the whole quantity, in the 150-pounder it is represented by ·015. So absolutely necessary is it to bring into comparison all these elements of dissimilarity in the results of guns, before you can draw any satisfactory conclusion. I will not take upon me to defend Sir William Armstrong's guns, or to argue from very erroneous drawings that they must be weak when in fact they are strong; that Sir William Armstrong will do to-morrow. Those guns have given proof of strength which no other guns have given. Perhaps no other guns have been tried in the same way: but the fact has been more than once mentioned that the 100-pounder gun has fired a continuous series of 100 rounds with the service charge, and cylinders increasing from 100lbs. to 1,000lbs., without exhibiting any weakness. On the other hand, forged guns, not on the coil principle, one of them made by Horsfall himself, and I allude particularly to Mr. Lynall Thomas's gun, have after long-continuous firing shown flaws of so treacherous a character, that that gun burst with a weaker charge than the charges with which it had previously been fired with impunity for a considerable space of time, and justifies one in feeling a doubt as to the possibility of forging those great masses; or at all events we may question the evidence of the strength of these great masses thus forged.

Lieut.-Colonel CLAY: That gun was made of steel, a new material; it was the first attempt at a gun of that kind, forged solid, according to plans with which we had nothing to do. I mention here publicly, it was burst by the jamming of the shot in the bore. The shot was such as must inevitably burst the gun.

Colonel LEFROY: I was at Shoeburyness on that occasion, and I do not think it burst from that at all. With regard to the exact method of rifling which should be adopted in a muzzle-loader, I should wish to state that the attention of Europe is divided between two systems of rifling. The French, the Spaniards, the Dutch, the Russians, have all adopted the system of muzzle-loading guns. On the other hand, the Austrians, the Prussians, the Belgians, and the Germanic States generally, have all adopted the breech-loading system, to which every objection that can be urged against Armstrong's gun is applicable in a three-fold degree, showing again that the game is not entirely with those who are playing for the muzzle-loaders.

Captain BLAKELY: At this late hour of the evening I will say a very few words only. In the first place, I will remark, that I was very much astonished to hear a person of Colonel Lefroy's deep scientific attainments state, that, if the friction in the Armstrong gun is very great, therefore it would follow, as a matter of necessity, that the shorter the gun, the greater the velocity, because, if that were the case, if we had no length at all, the velocity ought to be extremely high indeed. The fact is, seeing that friction is very great, and retards the ball, adding length to the barrel does not give so much additional velocity, as would be attained if the friction were not so great. With respect to the materials of which guns should be made, a mere expression of opinion whether wrought iron is good, or brass is good, is valuable; we ought to look entirely to facts. Now, as to the Armstrong or coil system. I have got a book in my hand dated 1845, giving an account of this coil system; it was tried, and abandoned on account of its total failure. The experiment was made by Mr. Treadwell, the President of the American Academy, a man of very high standing in his country. He made guns on that plan, not only in America, but also in France; he made them of a very considerable size. They had not in America at that time the large machinery which we have in Liverpool now, and they only made those guns the size of 32-pounders; they made them nearly as the guns are now made at Woolwich, of little coiled spirals of wrought iron welded end to end. I will read Mr. Treadwell's own words:—"A number of rings or short hollow cylinders are first formed by means of various moulds, dies, and setts connected with the powerful press before alluded to. The rings are upon their inner sides, and to about one-third of their thickness, of steel; the outer portion being of iron, wound about the inner steel ring, and the whole welded together. They are joined together, end to end, successively, by welding, thus forming a frustum of a hollow cone, the hollow being cylindrical. In giving form to the cone, in the press, its size is determined by a mould of great thickness and strength, which incloses the heated portion of the

cone, while a solid mandrel occupies the hollow cylinder, the fence being applied to setts upon its ends. The pores of the metal are therefore closed, and the metal condensed to a degree not to be obtained by the hammer. By turning and boring, this frustum of a cone is formed into the cannon, the breech being closed by a screw plug, and the trunnions fixed upon a band, which is likewise screwed upon the outside of the gun. The trunnion-band and trunnions are formed, like the cannon, by machinery moved by the hydrostatic press." That is a very accurate description of the process now carried on at Woolwich.

Sir WILLIAM ARMSTRONG: A very small resemblance, indeed.

Captain BLAKELY: At Woolwich, a screw is used to weld the short cylinders together, end to end, instead of a hydrostatic press, and the Woolwich guns are not lined with steel. Now, Mr. Treadwell's guns thus formed with steel lining stood very well, but Mr. Treadwell, thinking he could dispense with the steel altogether, formed some cannon of wrought iron, on the coiled principle, welded from end to end, and these utterly failed. I will read his words:—"During the trials of these guns at Fort Monroe, I was engaged in making the thirty-two pounders contracted for with the department of the Navy. These were finished in November 1844; and, although their weight was less than 1,900 pounds, the calibres being seventy inches long, one of them bore a succession of charges, commencing with eight pounds of powder and one of shot, and ending with twelve pounds of powder, five shot, and three wads. I ought to state, however, that in making some other guns of like size and kind, being unable to procure steel of proper quality for lining their bores, and misled by the extreme hardness of the small guns, I ventured to make them of iron throughout. The consequence has been, that, in two instances, guns similar to these made for the Navy in other respects, on being fired with very high charges, as sixteen pounds of powder, were enlarged by the ball making a lodgment of about $\frac{4}{100}$ths of an inch deep, and show a slight starting of the metal upon the external surface corresponding with the point of lodgment. The use of steel, however, is certain to obviate all imperfections of this kind hereafter." This, my Lord Duke, is evidently a faithful account of an experiment fairly conducted, and I think it should not be thrown aside as perfectly worthless.

Mr. SAMUDA: Yes, it ought; it has nothing to do with what we are making in the present day.

Captain BLAKELY: It shows if you are going to use a cast-iron bullet that the wrought iron will not stand it. Some time afterwards Mr. Treadwell in 1856 proposed another system of construction based upon an experiment which he formerly made, and upon other data. I wish to call your attention to the principle of the proposed construction:—"To obviate the great cause of weakness arising from the conditions before recited, and to obtain, as far as may be, the strength of wrought-iron instead of that of cast-iron for cannon, I propose the following mode of construction. I propose to form a body for the gun, containing the calibre and breech as now formed of cast-iron, but with walls of only about half the thickness of the diameter of the bore. Upon this body I place rings or hoops of wrought-iron, in one, two, or more layers. Every hoop is formed with a screw or thread upon its inside, to fit to a corresponding screw or thread formed upon the body of the gun first, and afterwards upon each layer that is embraced by another layer. These hoops are made a little, say $\frac{1}{1000}$th part of their diameters, less upon their insides than the parts that they enclose. They are then expanded by heat, and, being turned on to their places, suffered to cool, when they shrink and compress, first the body of the gun, and afterwards each successive layer, all that it encloses. This compression must be made such that, when the gun is subjected to the greatest force, the body of the gun and the several layers of rings will be distended to the fracturing at the same time, and thus all take a portion of the strain up to its bearing capacity." It thus appears that Mr. Treadwell, finding coiled-iron guns would not do, lined them with steel, and succeeded in making excellent 6½-inch guns; but that for larger sizes he afterwards recommended the plan I have now read.

A gentleman inquired whether any were made and tried on that system.

Captain BLAKELY: It is now used in America under the name of the Parrott Gun. The Parrott gun is a little thicker in the cast iron, which would perhaps weaken it rather more; but of all the Parrott guns which have been used in the present war in America only one has burst. The French tried precisely the same plan. Here is the figure of a French gun (Plate II. fig. 14); it is the same as the old 32-pounder gun; it has seven steel hoops upon it of about 2 inches in thickness, very carefully adjusted on the inside, and the consequence is, that guns of that description have frequently

been fired 2,000 times without destruction; and they are able to pierce the plates at 1,000 yards without any difficulty.

A gentleman asked what was the size of the plates.

Captain BLAKELY: 4½-inch plates. With 25 lbs. of powder they throw a 92-pound shot through 4½-inch plates, with 1-deg. elevation only, 1,000 yards. I have not seen them do it; but my authority is such that I cannot possibly doubt it. If any doubt is thrown upon the fact, I have here the official report of the Spanish gun (Plate II. fig. 15); they have tried the same gun; it is of very much less strength, as you perceive from the figure, than the French gun (fig. 16 is a section of the bore, and fig. 17 *k*, *l* are sections of the shell). The hooping extends a very short distance indeed, and yet with that Spanish gun they were able to fire 1,366 rounds with an average charge of 7 lbs. of powder and a 61 lb. projectile before the gun burst. The Ordnance Select Committee of Spain say in their report: "Although the 1,366 rounds fired with the above charge of powder and an elongated shot of 61 pounds are sufficient proof of the satisfactory resistance of the gun, the following observations will render still more apparent its excellence, and consequently that of the hooping system. During the first days of proof, 100 rounds were fired with intervals of only from one to one minute and a half. This made the gun so hot that it could not be touched with the hand. The following days 50 rounds were fired in the morning and 50 in the evening, with the same rapidity." With such rapid firing, I do not think any brass gun would have stood 100 rounds. But, supposing my argument to be entirely fallacious with respect to the necessity of hardness in the gun, still we must use cast iron, for the simple reason that we cannot get anything else.

General ANSTRUTHER: You can get cast brass.

Captain BLAKELY: I do not think brass has ever yet been cast the size I was about to say we must use, and that some of the American guns are being made now; they are making them of 17, 20, and 25 tons weight.

General ANSTRUTHER: Half that size of brass will do.

Captain BLAKELY: Therefore we have no choice, if it comes to huge guns. The late events in the mouth of the Mississippi river prove that it is not only necessary to have guns which will injure a ship, but guns that will stop a ship. We want a gun, from which one or two shots will stop a ship, and we want to place those guns in such a position that we are perfectly certain to hit the ships. I should prefer about 100 or 150 yards to 1,000, because the more one sees of artillery practice the more one would like to have the enemy pretty close. Should steel prove to be the best material, we shall find ourselves more limited, and more obliged to build the guns up because we are limited as to the amount of steel which we can get. We have no choice in the matter. We are obliged, by the necessities of the case, either to use cast iron, or to build up the guns in pieces, because we can only get pieces of a certain size.

Captain FISHBOURNE: Perhaps it is right I should answer one or two remarks which were made by my friend Colonel Lefroy. I can quite understand his being a little riled at my poaching upon his preserve, and his not adopting the recommendation which your Grace gave, that we should calmly talk over this subject. I am quite sure if he had calmly considered it he would not have said what he did. He has charged me with want of scientific accuracy in my comparison of point-blank ranges and different elevations. There is no doubt there is a great irregularity in the returns which come from his office, and they require a Philadelphian lawyer to discover what's what. I think I have distinctly stated to this audience what's what in these tables. I have explained distinctly where they come from, and I have explained what is the weight they are entitled to. There is no mistake with respect to the 68-pounder, and no mistake about those experiments at Portsmouth; they were all fired from a common platform. There is no difference in height of level there, and they are the results of the comparative penetration of those shots. I understand Colonel Lefroy to say, the guns will not stand if there is a reduction of windage. Now the windage of those guns is ·198, and they have stood that. It is a most difficult thing to give a relevant fact; it may be a fact in Colonel Lefroy's mind, but we want relevant facts; it is quite true if you put an undue tension upon an old 68-pounder, it will not stand; if you reduce its windage unduly it will burst; but the question is, Can you make a gun such as he is arguing for being made, built up if you please, or of wrought iron, that will stand it? I say, if Sir William Armstrong's gun will bear the enormous tension which he tells us it does, make them on the same principle, but let them be smooth bores, and let them have small windage; he says the guns will burst if they have small windage.

This which I have described as being ·233 in the 32-pounder (see Table D.) has been reduced by Monk to ·175, but we have got guns with less windage than that. Colonel Lefroy knows perfectly well that in the arsenal there are many guns which have the windage as low as ·120, and I believe even as low as ·1, very nearly one-half of that which I have described as the windage of the 68-pounder. But what is the fact with respect to the Armstrong gun, I mean the multigrooved gun? If there is no windage at all, either it has less tension, and does not bear the enormous strain he tells us it does, or else we can reduce the windage of our guns very materially. I do not profess to a great deal of scientific accuracy, but I do believe that I have taken pains, and that I am accurate as respects these statements.

On the motion of General Lindsay, seconded by General Boileau, the discussion was adjourned to the following evening.

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## ADJOURNED DISCUSSION.

Tuesday Evening, May 20th, 1862.

### Colonel P. J. Yorke, F.R.S., in the Chair.

Sir W. Armstrong, C.B.: Mr. Chairman and Gentlemen,—The chief argument adduced last evening by Captain Fishbourne, in support of his position that rifled guns were inferior to smooth-bores, was the alleged incapacity of the rifle to produce high initial velocities. This he attributed to the friction sustained by the cylindrical projectile in passing through the bore; but he adduced no experiment in support of that view. I, on the contrary, taking an opposite view, am enabled to refer to experiments which were made only last week, in which the rifled 12-pounder gun was loaded with a charge of one-fourth instead of one-eighth the weight of its projectile, the same in fact as the usual charge of the smooth-bore 68-pounder, and the result was that the initial velocity rose to 1,740 feet per second, being something more than the initial velocity of the round-shot gun; I can also appeal to experiments which have been made with lead-coated projectiles, having the lead considerably reduced in diameter, so as to facilitate the passage of the shot through the bore, and it was found that, instead of the reduced friction increasing the initial velocity, the result was rather the contrary.

Now, this is not at all difficult to understand, because you will easily see that by holding back the projectile until the powder is thoroughly converted into gas, that you will get a higher pressure upon the projectile, and impress a greater quantity of work upon it. But at the same time, those two facts of the greater initial velocity attained with the increased charge, and of the effect of diminishing the friction, put an end to the argument which was advanced last night by Captain Fishbourne, to the effect that the friction of the shot through the bore, was the cause of the loss of the velocity. Now, the fact is, the low velocity of a rifle projectile is due to a very simple and very intelligible cause. It is simply this, that the weight of the projectile is unusually large in relation to the charge. It is fired with one-eighth, instead of being fired with one-fourth, and of course it is perfectly natural that the velocity should be lost; in fact, the rifle projectile is generally equal in weight to about two spheres, and it is precisely equivalent to loading a smooth-bore gun with two shot instead of one. If Captain Fishbourne will try the experiment, he will find, if he double-shots his gun, notwithstanding the absence of that friction which he ascribes to the rifle-shot, the initial velocity of the two spherical shot will not be one atom greater than the initial velocity of the elongated shot of the rifle projectile. But although in the rifle projectile we get a smaller velocity, we, on the other hand, gain by the additional weight. The measure of the damaging effect of a shot is well known to be expressed by the square of the velocity multiplied by the weight; so that the energy or power of inflicting mischief in the case of a 68-pounder, which has an initial velocity of about 1,580 feet a second, would be expressed by 1,580 squared, multiplied by 68, the weight of the projectile. On the other hand, the energy or mechanical force of the rifled 110-pounder, would be expressed by 1,210, which, with the charge of 14lbs., is about its initial velocity; 1,210 squared, multiplied by the weight of the projectile, 110lbs. Those numbers work out rather large; but the result would be a proportion of about 17 to 16 in favour of the 68-pounder gun. That is at the muzzle of the gun; and this small difference, you observe, is not even proportioned to the difference in the charge; it has been clearly ascertained that, where the charge is increased, the effect is increased quite in the same proportion. Now I am

satisfied that the actual effects produced upon plates are in strict conformity to this rule, notwithstanding the representation of the effect which was expressed in Table A., in which the 110-pounder gun was shown to produce an effect expressed by 2·25, while the 68-pounder gun is represented by the very much larger number of 5·06. Now this is entirely contrary to the observed facts. I may also point out, that this amount of indentation expressed in that table, is not the usual indentation, by any means. The usual indentation of a 68-pounder shot is $1\frac{5}{8}$ of an inch. Then, if we are to take particular instances, I know cases in which the actual effect produced by the 110-pounder exceeds the effect produced by the 68-pounder. There are at present standing at Shoeburyness, two targets, made upon the laminated principle, one of ten inches thick, and the other of six inches thick; and it is unquestionable that upon those targets the 110-pounder, at the distance of 200 yards, produced a greater effect than the 68-pounder. In fact, there can be no doubt whatever, that the general effects are very closely approximated to what the theory represents. Sometimes the effect may take the form of indentation, and sometimes it may take the form of fracture, or bulging, or breaking the bolts; but I believe, generally speaking, the effect of a heavy shot, fired with a reduced velocity, will be to produce extensive fracture, while the effect of a lighter shot, fired with a high velocity, will be more of a penetrative character.

Now, Captain Fishbourne ignored the very important consideration that the velocity of the round shot was rapidly diminished from the time of its leaving the mouth of the gun—that, at a very inconsiderable distance, it was reduced to an equality with the heavier rifled projectile. The fact is, that, at a distance of 670 yards, the velocity of the two projectiles is the same. Now, at that very inconsiderable distance therefore, we have in the heavier shot a power exceeding that of the 68-pounder in the proportion of their respective weights—that is to say, as 110 to 68; at the greater distance, that superiority is still more marked. But if the effect be so much greater at 670 yards, it may also be greater in a considerable degree at a much shorter distance; and I am perfectly satisfied that even at 350 or 400 yards—in fact, within the distance of what is usually termed point-blank range—the penetrative, the battering, destroying effect of the 110-pounder is greater than that of the 68-pounder.

Now, there is another consideration which has not been noticed, and which constitutes the most important recommendation of the rifled gun; and that is the power of its shell. The bursting charge of the shell of the 110-pounder gun is 8lbs. of powder, whereas the bursting charge of the 68-pounder spherical shot is only $2\frac{1}{4}$lbs. of powder. Now, this is a prodigious advantage. It certainly may be said that shells are of no avail against iron-plated ships; but, on the other hand, I may say that neither 68-pounder guns, nor 110-pounder guns, with solid round shot, are effective against such iron vessels. Therefore, we must compare such guns, not for services for which they are not suited, but for services for which they are suited; and for operating against timber ships, and for shelling forts and arsenals, and troops on shore, there can be no question whatever, that the 110-pounder rifled gun is immeasurably more effective than the 68-pounder—in range, in power of shell. It has enormously the advantage for battering purposes; for penetrating purposes it has also the advantage, except for a very short distance indeed; and, even at this short distance, it is very doubtful whether it has any very decided inferiority; at all events, no inferiority greater than would be made up by increasing the charge equal to the one-fourth of the 68-pounder.

The fact is, what we want is a gun, in addition to our 110-pounder rifled gun, especially adapted for breaking through iron plates. That is what we really are in want of now; and that is what the discussion of this meeting ought to turn upon—whether that gun ought to be a rifled gun, or ought to be a smooth-bore gun.

Now, in entering upon that question, we are at once met with the very important consideration, which has not as yet received any attention, and that is the weight of such a gun, and the practicability of carrying it on board ship. It seems clear, now, that, to produce decided effect against iron-plated ships, it is absolutely necessary to use very heavy charges of powder—how heavy is not yet very distinctly ascertained; but certainly there is little prospect of producing any sufficient action with less than 35lbs. of powder. Now the question is, what will be the weight of gun capable of bearing 35lbs. of powder? If we make that a cast-iron gun, and if we make it in proportion to the 68-pounder—95cwt., which fires 16lbs. of powder—we should have to make it a gun of about $10\frac{1}{2}$ tons; but if we make it of wrought iron, and upon the coil system—which, I contend, affords the greatest strength for a given weight of material of any method which is now in use—I anticipate that we should be able to reduce that

weight to about six tons, or something under. This, however, is for a smooth-bore. If we make the gun a rifled gun, then I do not think it will be prudent, if we are to use it with a charge of 35lbs. of powder, to go below eight tons. Although I fully admit and contend that the rifle has immense advantages over the smooth-bore, the question is, whether the navy can afford to carry that additional weight for the sake of obtaining the advantages of rifling.

Now this question requires to be considered under two aspects: first, as regards present ships, and, secondly, as regards future ships. As regards present ships, naval men seem to be agreed that it is not possible to carry broadside guns much heavier than the present 68-pounder; or, at the very most, that six tons must be the limit.

It is a nautical question purely; and therefore I cannot venture to give an opinion: I can only adopt their dicta upon the subject, and, assuming them to be correct, I do not see what alternative we have, but to make that gun a smooth bore, in order to keep it within the weight. It is, therefore, as a matter of necessity, not as a matter of choice, that I think this particular gun ought to be made a smooth-bore. As regards future ships, the case may be different, because I believe the advantage of heavy guns on the rifled principle will in future be so fully recognised, that the construction of ships will be made to bend to the necessities of the case, and to carry guns of a much heavier calibre, and that those guns will be rifled.

I will now endeavour to explain why it is that a rifled gun must be heavier than a smooth-bore, and, for this purpose, I will direct your attention to the longitudinal diagram which I have drawn (see Plate I. fig. 11), showing the bore of a gun of 9¼ inches in diameter, with a cartridge containing 35 lbs. of powder, and measuring in length 17 inches, and having a round shot placed before it weighing 100 lbs. Now, if I were to rifle that same gun, and substitute for the round shot a rifled shot of twice the weight, then it must be clear that the powder having a greater mass to move, the gas will meet with a greater resistance, and will get up a greater pressure behind the shot, and it will be necessary to add additional strength to resist that extra strain upon the gun. But it may be said that we cannot oppose a greater resistance to the shot, and thereby get up a greater pressure, without impressing upon the shot a greater amount of work, and this I am quite prepared to admit. I believe that, if the bores be the same, that if the powder can expand to the same limit before it escapes into the air, there is a greater quantity of work—a greater power of inflicting damage—resident in the heavier rifled projectile than in the lighter 100-lb. shot. But it is, nevertheless, equally necessary that we should add strength to that gun, and, in adding strength, we must necessarily add weight in larger proportion, because we can only add the material to the exterior of the gun, and every additional layer that we apply being of a larger circumference, involves an additional weight more than proportionate to the increase of strength; therefore it is that, in making that gun of sufficient strength, we make it heavier than is equivalent to its greater strength.

But it may be said, why not keep the weight of the shot the same, and reduce the bore, so as to enable the same proportions to be retained. Now, we will try that alternative; and here we have it represented. I have in this case taken the bore at 7½ inches, which, I believe, is approximately correct for a round shot of 50 lbs. (See fig. 12.) In this case, by making the projectile of the same proportion as in the other case, we make its weight 100lbs., or the same as the sphere in the other case. Now, to apply the same cartridge—the same quantity of powder—because that is the condition,—the area of the bore being only one-half what it was before, it is necessary to make the cartridge twice the length, as represented here. Hence, therefore, although the circumferential area exposed to the pressure of the powder is diminished in the proportion of 7½ to 9¼, yet the longitudinal surface is increased in the proportion of two to one; and, consequently, we have a far greater surface exposed to the pressure of the gas at the first instant of ignition in the one case than we have in the other. The strength of the gun must therefore be continued further forward. But not only that, after the shot of the smaller bore has travelled through once the length of its cartridge, the length of bore filled by the gas will be twice 34 inches, or 68 inches; whereas, when the other has travelled through once the length of the cartridge, so as to give double capacity for the powder behind, it will only have travelled 34 inches; and therefore we must bring forward the corresponding strength of the gun in the one case to 68 inches, and only to 34 inches in the other case. It is clear, therefore, that we gain nothing by reducing the bore, but rather the contrary.

Then there is another consideration. In order to get the same duty out of the gas produced by the powder, we must afford it the same number of expansions. Suppose the barrel to be seven times the length of the cartridge, which would make it at 119 inches. In that case we get in the larger bore seven expansions of the gas, and then, at the end of that, it escapes into the atmosphere. But, supposing we make the other only the same length, we shall then only get three-and-a-half expansions; and, consequently, we do not get the same duty out of the powder. It is necessary, therefore, with the small-bore gun, in order to make it equally efficacious in that respect, to double the length of the barrel; therefore we must either sacrifice efficiency, or we must make the gun inordinately long and inordinately heavy. Now, if we could make a rifle shot of the same weight as the sphere, then we should avoid this difficulty. But, if we do so, we, in point of fact, gain very little advantage over the round shot. It is only by the elongation of the projectile that we gain the advantages which are due to rifling.

Another alternative is to rifle the gun, and to use the high charge only with the round shot. It is most important to preserve the advantage which the rifling gives in regard to shell, for which a reduced charge might be used: that is to say, we should have it as a rifled gun fired with a lower charge, and as a smooth-bore gun with a higher charge. The only question relating to this is the practicability of using round shot with a grooved gun. There is much to apprehend on that ground, because, even without any grooves at all, we find, by using these extremely heavy charges there is a tendency to indent the gun; and any system of grooving would materially increase that tendency. It remains to be proved, however, whether by using *sabots*, that can be obviated. If it could, it would probably be the best way out of the difficulty to have your gun only sufficiently strong and only sufficiently heavy to be enabled to use it with the full charge, as a round-shot gun, and to use it for throwing shells of greater weight and large capacity with a reduced charge.

Captain Fishbourne adverted to a few additional topics, which I think I may very quickly pass over, as I feel I have already occupied much of your time. In the first place, he represented the trajectory of the 68-pounder round shot, as greatly superior at small elevations to the trajectory of the 110-pounder shot. There is a diagram here (Plate I. fig. 13), which shows the effect of a shot from a trajectory passing high over the top of a ship, while another either strikes the ship, or is very close upon it. Now, clearly, this is a very distinct way of showing the effect; but it must not be supposed that these are the correct delineations of the two trajectories. The difference between the trajectory of the 110-pounder and the 68-pounder, even at very low angles, is exceedingly small—very small indeed—nothing to be compared to what it is represented here; and at longer ranges the difference is greater in favour of the rifled gun.

Another point which Captain Fishbourne took was the straightness of the ricochet obtained by the round-shot gun. No doubt upon perfectly smooth water, the round shot does ricochet straighter than the rifled shot, although when the angle is very low, even the rifle shot ricochet very straight. But upon an undulating surface, such as you must almost invariably have at sea, the ricochet, whether it be with the round shot or with the rifled shot, is exceedingly wild; therefore I do not think that amounts to very much.

Captain Fishbourne criticised the coil system of construction. He referred to a diagram (Plate I. fig. 2), and pointed out various overlappings. He stated that it must necessarily happen that it would draw asunder, and disintegrate in places, and so on. However, all that is met by the fact that it does not take place; and I think I need not argue the question further.

Well, he objects to breech-loaders. All I say is, that breech-loading has its advantages. The most conspicuous of those advantages are, that you are enabled to use a long powerful gun in ships of small beam. If you use muzzle-loaders you must run them in-board, and to do that you require a great breadth of beam; consequently the armament of narrow ships is limited to short guns. In addition to that, you expose your men at the ports.

I think the only additional point I need advert to is, that Captain Fishbourne attaches great importance to a diminution of windage in the round-shot gun, and he produces here a table (see Table E), the correctness of which, although he produces his authority, is glaringly wrong. Here is a difference of windage! There is ·025 in that case; and here you will see ·170; a difference of windage, which is scarcely more than we have in our 32-pounders: the range in one case is represented as 288 yards, and in

the other as 52 yards. Everybody that is in the least degree conversant with these matters knows that that cannot be.

I do not know that I have anything more to say, unless it be to recapitulate that my views are all in favour of rifled ordnance. I am perfectly satisfied that the future gun of the navy will be a rifled gun. But, taking things as they are, and looking to the necessity of accommodating weights and so forth to existing ships, I think there is a strong case made out for the use of smooth-bores as broadside guns, for the special purpose of grappling with iron-plated ships.

The CHAIRMAN: Will you allow me to ask, Sir William Armstrong, whether you think there will be little difficulty in making rifles to bear charges of the proportion of one-fourth instead of one-eighth the weight of the projectile?

Sir WILLIAM ARMSTRONG: I think there will be great difficulty. It is only necessary to look to that diagram (Plate I. figs. 11, 12), and see what cartridges you would require. In one case you would require a cartridge twice the length of the other.

Admiral Sir FREDERICK GREY: I should like to ask one question. Would there be any difficulty in coating a spherical shot with lead, the same as an elongated shot, so as to use it without any danger to the bore?

Sir WM. ARMSTRONG: There would be no difficulty in attaching zinc solder, by Mr. Bashley Britten's plan; but I do not very clearly see the object that would be attained by it.

Sir FREDERICK GREY: I was alluding to what you said in reference to using the spherical shot or the elongated shell.

Sir WM. ARMSTRONG: To avoid indentation?

Sir FREDERICK GREY: To avoid injury to the rifling: whether you could not avoid injury to the rifling with a spherical shot?

Sir WM. ARMSTRONG: Oh, yes; it is quite feasible to coat the round shot.

Colonel WILFORD: If I may be permitted, I should like to ask Sir Wm. Armstrong a question. I beg to ask if he has directed his attention to the effect of the recoil in heavy guns, with a charge of 35lbs. of powder? The present 68-pounder is rather a lively gun when it is fired. Even now the recoil is in the proportion of 1 to 32. Therefore it strikes my mind, as a practical man, the difficulty might arise in managing the recoil of so light a gun with so heavy a shot and so powerful a charge.

Sir WM. ARMSTRONG: I have considered that subject a good deal; and I have certainly arrived at the conclusion that, by a proper system of compressors, you can control the recoil. I do not think it will be easy to reduce the weight below that limit; but that, again, constitutes one of the difficulties of using rifled guns with those high charges and heavy shot, because the recoil is much more affected by weight of shot than by velocity. The work impressed upon the shot, is in the ratio of the square of the velocity multiplied into the weight; but the recoil of the gun is in the direct proportion of the weight of the shot, and not of the velocity; and, therefore, the recoil would be more severe in the rifled gun than it would be in the other. And, consequently, that is an additional reason for adding to the weight of the rifled gun.

Colonel WILFORD: The necessity, in fact?

Sir WM. ARMSTRONG: Yes.

Mr. CHARLES LANCASTER: The question that has been so ably brought before the notice of the meeting by Captain Fishbourne, is without doubt one of very great importance, and to it, I am sure, the energies of the mental powers of the many distinguished gentlemen round the room will be devoted with much anxiety. On the last occasion our noble Chairman alluded to a state of doubt and uncertainty, which those in power and the profession generally felt in reference to the great question of the rifle gun for the service; and he alluded in terse and proper terms to the question as to whether it should be of cast iron or of wrought iron, or whether a compound of both cast and wrought iron. It was a question on which he expressed doubt and uncertainty, and one that required elimination and careful argument, in order that the true principles upon which our naval gun should be constructed might be placed in an intelligible and proper form, for the determination of those who hold authority in the country. With that view, perhaps, it may be as well if I endeavour to take the matter up, and to express, as far as in me lies, my humble opinion as to the merits of the various methods of constructing naval guns, and perhaps to show some few points about it, to the notice of the meeting.

First and foremost, I think it can be scarcely questioned or denied, and least of all will I attempt to question or deny, that to the distinguished director of rifled

ordnance, Sir William Armstrong, we owe very much, for the very admirable and perfect specimen of a wrought-iron gun he has presented to the British public. As far as regards the question of muzzle-loaders, I think it may be held as decided, that a gun of surpassing strength and wonderful mechanical execution has been produced by that gentleman, and to him we owe much. The question of the superiority of wrought iron guns for field purposes, I think, can scarcely admit of a doubt. The superior lightness which it is possible to give to these guns affords very great and grave arguments in their favour. I am not now, gentlemen, touching upon the question of breech-loaders at all, but merely upon the question of the use of wrought-iron for the purposes of artillery. In naval guns another question comes into play, which was very properly touched upon by Sir William, and that is, the weight of the guns. Now, when wrought-iron guns were first manufactured for the purpose of naval guns, I think it will be within the remembrance of many of the gentlemen who surround me, that it was proposed to make those guns very considerably lighter than the proportion heretofore held as desirable in reference to cast-iron guns. The proportion of the cast-iron 95-cwt. gun, of which so much has been said, is something in the ratio of 156·5 to 1, to the unit of the projectile, and the wrought-iron gun first introduced as a naval gun was very little more than half of that ratio in proportion to the unit of the projectile; therefore of necessity limiting the initial velocity that can by any possibility be given to the projectile, having regard to the proper conservation of the carriages. Gradually, as experience has progressed, the weight of the wrought iron has steadily gone up; that which was 65 cwt. is now 85 cwt., and perhaps it will be found desirable to make it more; therefore, we come to the very tangible proposition: a given weight being absolutely necessary where a given weight of projectile is to be projected with a high velocity, are we to be confined to wrought iron? Is it true that wrought iron is the only material? Is it true that a very beautiful mechanical specimen of engineering, to be produced at a very large price, is the only material, or is it possible, by some other adaptation of, or combination of, other materials, to yield an equivalent result—bearing in mind you have to deal with a certain fixed weight, below which you cannot go? Assuming that proposition to be a somewhat intelligible proposition, and bearing in mind that one important point in reference to the present construction of wrought-iron guns has not been touched upon, and that is this, that they must be not only fired from, but fired at, in actual warfare, I think that that must not be lost sight of in taking into consideration the construction of the present wrought-iron gun. Guns will sometimes be hit, you know, gentlemen, in action; and if guns are hit on the muzzle that are rather thin and built-up with several layers, they are open perhaps to grave objections, which I need not explain to practical men. But it is practically obvious that wrought iron will indent, and that, being indented, if it were a muzzle-loading gun you could not load the gun again. I mean, supposing a three-pound grape shot at 100 yards, such as is used in a naval action, struck it, it would be a serious question whether the gun would not be subject to rupture. Now, cast-iron does not indent in that way. You will see in the Arsenal at Woolwich several guns that have suffered very severely at Sebastopol, from being struck at the muzzle, and have been fired very repeatedly afterwards, and are still fit to do a little more service, although they are of cast iron. Therefore, I say, without condemning the use of wrought iron, and without at all interfering or wishing to detract from the value of wrought iron as the means of securing an enormous amount of endurance in a naval gun, that it is worth while to consider, to pause, to deliberate, and see whether there is not some hope of being able to render cast iron a still available agent for naval purposes at the present day, when high velocities are so exceedingly essential, when the cast iron is fortified by a proper application of wrought iron on its exterior surface. With that view, with your permission, gentlemen, I will, with the aid of the many diagrams here, endeavour to point out what has taken place in reference to this question of the possibility of strengthening cast-iron guns, hoping that what I may have to say, may elicit some discussion, some expressions from the many distinguished officers round the chair, and that it may assist the authorities in arriving at a tangible decision in regard to the matter.

Early in October, 1859, I had the honour of submitting to the Secretary of State for War a proposition in reference to the strengthening of cast-iron guns that appeared to bear some new and peculiar features. As you see round the theatre, gentlemen, there are many specimens of various methods of strengthening cast-iron guns, some in use by the Spaniards, some by the French, and others that have been tried in various forms under the superintendence of that very able body of distinguished officers with

whom I have been in contact for so many years, the Ordnance Select Committee at Woolwich, and who have given much time, great attention, and their most earnest endeavours to the elimination of this matter. The cast-iron gun, I need not observe, has been the subject of many experiments in regard to the possibility of strengthening the cast iron by placing on its periphery wrought-iron, in the shape of rings of various thicknesses and various forms. A distinguished American gentleman, mentioned by Captain Blakely, Mr. Treadwell, and Captain Blakely, Mr. Hughes, and many other gentlemen, have devoted much care, time, and attention to the matter, and from time to time many experiments have taken place at Woolwich, and, I believe, in the course of the experiments, some 10,000*l.* of public money was expended to see if it was possible to produce a strengthened cast-iron gun. But until October, 1859, the whole of those experiments went to this fact, that the gun was turned more or less cylindrical on its exterior surface, and hoops, more or less thick, of wrought iron, were carefully bored, heated, and shrunk on to the exterior of the gun, but without any regard—I beg you will bear with me in this particular—to the longitudinal strain that results to the gun upon the combustion of the powder; that is, the powder acting in all directions alike, acting on the rear end of the gun as well as on the side of the gun. If you leave the end of the gun in its normal state, and merely depend on the tensile strength of so many inches of cast-iron, of course it is no use strengthening it on the periphery of the gun, and that gun will burst as nearly as possible in the same time as if it were wholly of cast iron. That was the result of these experiments, and so much so, that, in the results at the proof-butt at Woolwich Arsenal, guns burst after 51 rounds of destructive proof.

Now the propositions brought to the notice of the Select Committee on that occasion embraced another principle. Is it not possible, the normal end of the gun being in the normal condition of cast-iron, deficient in tensile strength, by enveloping the breech end of the gun in some degree, so to brace and truss the gun together, that it will sustain a very much more severe proof? Efforts were made in that direction, and a gun was prepared in which the rear end of the gun was turned down over an inch and a half on the posterior quarter, and a longitudinal truss was fitted on over it, in this way enveloping the ends an inch and a half, and completely embracing the gun; the wrought-iron hoops being then shrunk on over the longitudinal truss. A very remarkable result was given by this experiment. The gun immediately went up in scale of strength under the same condition of ten pounds of powder, the unit of projectile of a 32-pounder, and so on, increasing every ten rounds one unit; it went up to 81 rounds instead of 51. I confess to be a believer in figures; if mathematical formula mean anything, and if supporting the periphery of the gun for 1½ inches does really give, which this gun really did give, 31 rounds of destructive proof, plus any other; then, if you believe Hart's formula, I think you will find that if the whole rear end of the gun could be cut off, and if, instead of merely supporting the rear end of the gun for 1½ inch longitudinally, you support the whole of the rear end of the gun by a solid case of wrought iron, and transfer the longitudinal or tensile strain on to the wrought-iron jacket, you have done a great thing. (See Plate I. fig. 5.) I believe you will get from a cast-iron gun strengthened in that way, everything that you can get from a gun for the naval service. That is my impression; I may be in error; I think there is reason on the side of the proposition. It was argued carefully before the Select Committee of Woolwich; they gave it their most serious deliberation, and we have reason to believe that they thought that, considering the fact that £10,000 had already been expended on experiments, and as the proposition itself was novel and promised great results, it was desirable that it should be tried. I have reason to believe it was so reported by those gentlemen, and I gravely regret it was not thought desirable to try it by those who held the higher authority—of course for the best possible reasons which I cannot enter into now. The proposition, as it now stands, is a proposition that holds out every probability of success, as far as it is possible, by mathematical deduction, to assign a reason and a cause. I believe that it would be successful; but still it has been deemed not proper to try it, and so it has not been tried. That is precisely the condition at the present moment. I wish it were to be decided otherwise, and I hope yet to see, for the interests of science, and for the definitive settlement of a question of so much interest, that point, which I still hold to be very interesting indeed, should be tested in a proper way by the proper authorities.

Having so far brought to your notice the different points that occurred with reference to the strengthening of cast-iron ordnance, I will now pass on by a sort of transition to

our old friend the cast-iron ordnance. And I wish to mention that subject in order to elucidate and bring before your notice some very interesting trials that were commanded by the late lamented Lord Herbert. That was the question of the proper mode of rifling the cast-iron gun of the service. We know that, as far as regards timber vessels, the cast-iron gun of the service was capable of rendering, when rifled, or even unrifled, very great and efficient service in the defence of the country, and it was thought at the time, that if it were possible to determine once and for ever whether the gun would bear the process of rifling, beyond question and beyond cavil it would be information to the authorities; and at any rate it would determine what method or system of rifling, whether applied to cast or wrought iron, would give the most satisfactory results under all the contingencies of the service. With that view, some seven or eight gentlemen—the names are all placed here—were called upon by the War Department to contribute their plans and give their advice, and to state their reasons, and to give their opinions, as to the best methods of cutting the interior form of the cast-iron service gun in the most advantageous way, in their impression, for the public service. Now, those trials are nearly completed, I may say concluded. I do not wish, it would ill become me, to criticise the plans of so many gentlemen who have devoted their time and attention, and who, doubtless, are of opinion that their plans are preferable to others. I do not propose to criticise the various forms of groove, but merely to give the results as they have occurred as a fact. I have no doubt that many gentlemen will follow me who will advocate their own particular form, and will give good reasons for your consideration; but, having to deal only with the facts of the matter and the results of the trial, I think it is a course open to no cavil, and will simply be for the information of the meeting.

The figures on these diagrams are all strictly correct, giving the weight of the shell, the number of grooves, the turn of rifling, the weight of the powder employed—every particular. I will not pledge myself to precise accuracy; there may be some trifling decimal as to the depth of the particular scale to which they are drawn; but still, for all tangible purposes, the shape of the groove, the length of the projectile, are preserved with fidelity. Some are lead-covered projectiles, some with the zinc represent Sir William Armstrong's shunt plan, some are grooves with iron fitted into them, and others have no grooves or anything of the kind. Now, it appears, without specifically relating which particular plan may be referred to, that some four or five guns on particular plans had a tendency to burst, and do invariably burst before the 50th round, some invariably burst before the 20th round, some went on to the 300th round and burst, and others now stand having fired 1,000 rounds, and are still in a perfect condition. Therefore, without particularising, or without adverting to the particular plans that have stood 1,000 rounds, or that burst at the 300 rounds, I think it may be taken as a datum that cannot be disputed, that if, with a certain standard of value which we may term the 32-pounder gun, it is proved that not merely one or two, but three, four, and five guns of a particular description burst before the 50th round, and that some three or four rounds of a particular description burst under 200 rounds, and that of another description two guns burst at 300 rounds; and on the other hand, that guns of a particular description stand 1,000 rounds, there is good ground for those who have the direction of these matters to say, and reason very fairly by analogy, that, whatever may be the reason, this particular form of grooving or rifling has yielded a more satisfactory result, inasmuch as the guns have resisted to a much greater extent than the others. I think it is a sound ground to go upon, and it is also clear and incontestable that if you admit the premises in reference to the cast-iron gun it cannot be denied that the same rule is applicable in reference to the wrought iron, that if you say you have a better result with the cast-iron that it will be also led to apply to the wrought iron. But I may be permitted to mention this, that a most remarkable fact has come out in these experiments, and that is this, that in reference to the lead-coated projectile, if it is put on evenly as in some projectiles in a thin form, and you pass one-eighth of the weight of projectile as a charge, the lead is given off from the projectile on the discharge of the gun in the shape of an amber-coloured cloud, called lead fumes. I purposed showing the experiment, but, unfortunately, my apparatus became broken; but if you throw lead in a finely-divided form upon an intense flame it is given off in fumes at once. It will be a pretty experiment for a lecture-table, but still it has been so often witnessed by gentlemen who have seen the lead projectiles fired, that it is scarcely worth while repeating it before the professional part of the audience; and, furthermore, it is known that, if you exceed a charge of one-eighth, and go to the charge of one-fourth, you are then

exposed to another source of inconvenience, the positive melting and remaining of the lead in the bore of the gun; that is the result of the experiment at Shoeburyness alluded to by Col. Lefroy. If, on the other hand, the lead is put on thickly and mechanically, as in another description of projectile, and you go beyond the tenth of weight in the charge of powder, as is proved by a great number of elaborate and practical experiments at Shoeburyness, the cast-iron gun bursts; that is absolute, there is no escape from it, because it applies to all modes of rifling in which the lead-coated projectile is used. If, on the other hand, you fit into a groove, of whatever form you like, an iron contour on the outside of the shell, or this kind of thing, or anything of that kind (pointing), after a certain number of rounds the edges of the grooves crush, and immediately on the crushing of the edge of the grooves, the bursting of the gun follows as matter of course. So that these experiments with the experimental rifled gun have yielded, I believe, to those who have the direction of all matters concerning artillery, very important, and, I believe, very valuable results.

The question of initial velocity has been more than once alluded to, especially by Capt. Fishbourne and by Sir William Armstrong. Now Capt. Fishbourne, I believe, held that it was impossible to obtain sufficient initial velocity, if I understood him correctly—I hope he will correct me if I make any error—with the rifle projectile; and he grounded his preference of the round shot, or the old service ammunition, in comparison with the elongated projectile, to its very greatly increased initial velocity in comparison with the rifled gun at present in use. Now, while admitting the value of the high initial velocity of the 95-cwt. 68-pounder gun, I must submit, with all deference to Capt. Fishbourne, that it is not at all proved, and never has been tried to the present moment—until Sir William Armstrong mentioned that a 9-pounder gun fired a few experimental shots at Shoeburyness the other day with a quarter charge—that the rifled gun had ever been tried with approximate charges of powder in comparison with the service 68-pounder gun. Now it is not at all clear that it cannot be done. I am of opinion that it can be done; in fact, I have been for months endeavouring to impress this matter upon the attention of the authorities; and so far back as the 13th of March, 1862, I had the honour of addressing a letter to the Select Committee on this very subject. It might be too long to read, I won't trouble you with it, but the main point is this: enunciating that the rifled guns had never been tried upon equal terms with the service gun, or what is known as the service gun, that they had never been tested with high initial velocity, and briefly suggesting the method by which guns could be constructed and tried, having the rifle motion communicated to the projectile, using one fourth of the weight of powder of that projectile, and having an initial velocity, as I said in my paper, of 1,650 feet per second, I firmly believe that with the advantage which up to the present moment has incontestably been held at certain ranges by the service or round shot, would be found to vanish completely if tested against rifled shots with high initial velocity, at the same distances. I can firmly believe that it is perfectly possible, and in fact I may say that to my knowledge it has been done, and I have communicated that knowledge to the War Department. It has already been done with rifled projectiles capable of punching through the thickest plate known in modern warfare—it is a misnomer to say modern warfare—but for the purpose of defending iron ships they have already been punched and perforated by elongated rifled projectiles at high velocity. I have by letter communicated that to the War Department, and offered to place drawings at their disposal. It is needless to say more upon that point. In reference to this paper of the 13th of March, 1862, I believe it will be recognized by those who have authority, that it was one of the first recognitions of the important point of communicating to rifled projectiles a high initial velocity, and I do not doubt that when it is fairly tried, not only will it give results that will surprise the profession, but I do not doubt that the very elaborate experiments of the Iron Plate Committee will have to be gone over again, and I hope, with results that will afford great benefit to those who have the charge of the construction of our ships, and no doubt afford a mass of information to the profession, and amply reward those entrusted with the onerous duty of testing those experiments again. I had the honour of laying before the Select Committee, plans for the brass gun of the service—converting it into a rifled gun—which embraced a distinct proposition, and stated that it was not necessary to have a large amount of ovality, but that the ovality would be something like what it is in the 9-pounder gun, not quite one-tenth of an inch, and such an arrangement made, without the use of lead upon the shot, that upon the explosion of the powder the projectile would conform to the bore, and receive the rifle motion with perfect facility.

I regret that it was not thought necessary to try it at the time, but it is one of those propositions that will come round in time, and I have no doubt will be tried hereafter.

Without detaining you longer, permit me to make one observation. Reference has been made both by the noble chairman and by Sir William Armstrong to the question of breech-loaders. It is a moot question whether the gun for the naval service should be a breech or muzzle loader. I confess I am not satisfied that the finality of breech-loading ordnance has yet been arrived at. I believe Sir William also expressed himself to that effect to the civil engineers, when on a late occasion he addressed them, that in reference to the heavy ordnance, he was also of opinion that further experiments were necessary, and he, in a most philosophical and admirable manner, explained to the meeting some further experiments he was carrying out for the benefit of the country. Bearing in mind that the observations I or any other gentleman may make, are solely for the benefit of the service, I may perhaps be permitted to explain to the meeting a very admirable plan; it is not my invention, but I believe it holds out great promise and is deserving of the very gravest consideration, and I am sure the great talent of Sir William Armstrong could not be better developed than by testing the thing in that fair and equitable way, that I am sure he will feel a pleasure to do when it is brought before him. Some four or five years ago I had the honour of bringing it before the Select Committee, and through the courtesy of Mr. Clay I had an opportunity of bringing to the door of this Institution a gun made somewhat on this plan, but unfortunately its weight precluded the possibility of introducing it into the theatre, so that I very much regret I cannot have the opportunity of showing the actual gun itself to the assembly. Still, if you will bear with me one moment I think this will sufficiently elucidate the matter and bring its prominent features to the notice of the assembly. I must premise by saying I have no doubt you remember the statement in the various papers that a wonderful breech-loading gun had been tried in France, that it was carried wonderfully swathed up and hidden, great secresy observed, and no one knew what it was. I am informed, and have every reason to believe it to be perfectly true, that the breech-loading gun tried on board the "Gloire" is substantially on this plan, and that the success that it has met with before the French authorities is such, that my impression is that it is well worthy of a trial and active consideration at the hands of our authorities. The breech-closer is simple, and, without criticizing that, or saying one word in reference to the many plans of breech-loaders that have been brought before the authorities, I believe it may be held as a definition that a breech-loader for artillery purposes is perfect in proportion to its simplicity. Now simplicity, I believe, may be defined as meaning fewness of parts; therefore, to hold to the definition as correctly as possible, if you have a gun which consists merely of two parts, the barrel proper and the closing screw, I think it must be held as an advantage over another kind of breech-loader consisting of more parts. I may be in error, but that is my impression. Now, you will perceive that the circle represents the cylindrical portion or bore of the gun; that of course may be rifled in any form, or non-rifled, as it may be required; and the posterior portion of this gun is so arranged that the closing screw which is represented here is not in an axial line with the bore of the piece. Consequently the screw itself may be termed as excentric to the bore. It is therefore obvious that when you wish to load the gun you have merely to give the handle a half-turn, and the hole which perforates the breech-screw, which is of a very massive kind indeed, is brought precisely in a line with the axis of the piece. You then insert your charges—there are easy means of regulating your charge so that it cannot work too far—that is very easily done, and with one half-turn of the screw the gun is thoroughly closed, and the resistance opposed to the charge is of course very enormous, because the screw is very great indeed, very thick and very solid, and not liable to be broken or cracked by the discharge of the powder. It occurs to me it is well worthy of the serious consideration of those who have authority in these matters, and with that view I thought it would be interesting to the meeting to bring a matter in which I have not the slightest interest before you for their consideration.

I have somewhat overstepped the time. If I have said anything that may at all elucidate the question of naval guns, it will have afforded me the greatest possible pleasure. And, in conclusion, I may state this, that I do believe, that, for a naval gun, it is of the highest importance to have a gun of large calibre and heavy projectiles, and a proportion of powder not less than one fourth of the weight of that projectile, let it be rifled or not. And, in reference to the question as to the possibility of shooting the ordinary service shot from a rifled gun, I think that may be disposed of in two words.

The Lancaster gun tried in the Crimea not only fired elongated projectiles but the service projectile, and it is on official record that many of those guns before Sebastopol fired as many as between 2,000 and 3,000 rounds of the service projectile; they have been brought home to England, and are still, some of them, as far as the bore is concerned, in an efficient state, and that there is no difficulty whatever, and it is so reported by the Select Committee of the period, in firing round projectiles from the oval-bore gun, and that the accuracy and range of the round projectile when fired from a gun so bored is as great and as accurate as the service gun fired in the usual way.

Colonel WILFORD: Although I must despair of saying anything equal in interest to that delivered by Sir William Armstrong and my friend Mr. Lancaster, I hope I shall compensate for it by my brevity. I may say, incidentally, having had the honour some years ago of belonging to what was called the Lancaster Committee on Mr. Lancaster's gun, that, in conjunction with Sir Thomas Maitland, I directed one of the experiments just alluded to. His gun, although rifled on the oval bore, to our apprehension threw round shot quite as well as the ordinary bore. I merely mention that, as I happen to be cognisant of the fact. I wish to say a word or two about cast-iron. What Mr. Lancaster said is perfectly correct, and I may state, on the authority of Sir Richard Dacres, who commanded the artillery in the Crimea, that some 68-pounders having been lent to the French, they endured 2,000 rounds. We also know that at the siege of San Sebastian our iron guns stood 300 rounds a day of full breaching charge. It was by means of these iron guns, the French using brass, that the Duke of Wellington was enabled to open his breaches sooner than was expected, and before the French could relieve the place. It could not have been done but by the use of iron. Every one is cognisant of the bursting of the mortar at Sveaborg. In a very learned and elaborate lecture delivered in this Theatre it was endeavoured to be established that the failure was due to the form of construction. It was shown there were certain lines of fracture, by certain laws of crystallography, where the fracture must necessarily take place. But other mortars were made on these same lines, and they stood 2,000 rounds fired quickly with 20 lbs. of power, showing that the form of the gun is mere moonshine compared with the quality of the metal. It is clear, then, that cast-iron will do the work if you can get it. But there the difficulty arises; you cannot get it. I believe a combination of so many circumstances is required—fine metal, great heat, and so on—that no ironfounder would undertake to produce two pieces alike. Therefore, I think we must come to the same form of wrought iron—either on the coil system, which I believe is the most satisfactory, or on some other mode. Allusions have been repeatedly made to the charge of one-fourth. That is one-fourth the weight of the shot. It may appear to the audience that that is the normal charge. But it is by no means so, for heavy battery guns. Before our powder was improved the charge for our guns in the navy 80 years ago, was one-half the weight of the shot. But our powder being very much improved, it was thought safe to reduce it to one-third. The French very recently, if not now, with their land service of brass guns, not being able to trust their cast-iron, fired with one-half the weight of the shot.

A VOICE: They do still.

Colonel WILFORD: They do still. Therefore, in order to get the best effects, we are not at all necessarily confined, if we have a gun strong enough, to a charge of one-fourth the weight of the shot. The reason why a 68-pounder is confined to a one-fourth charge, is, because the navy make a great objection to weight. I was at a joint Committee of Artillery and Naval Officers, when we proposed to have heavier guns. "Here," we said, "is your 68-pounder, which only weighs 95 cwt.; you can only fire with one-fourth the weight of shot." They said, "We cannot work anything heavier satisfactorily on our decks." That was conclusive. We know that Captain Dahlgren has introduced guns of 7½ tons—the 11-inch gun—showing that guns of great weight can be used. Something was said about penetration being as the square of the velocity. That is to say, with a double velocity you have four times the penetration; and with a treble velocity nine times the penetration. That, then, is the direction to go in, to have the best gun we can get for naval service which can be fired with at least one-third the weight of the shot, I should say three-eighths.

Mr. HADDAN: Instead of expressing any opinion, I wish to state what has lately been done. Two years ago, when Captain Blakely read a paper here, I expressed an opinion that hooped cast-iron guns would not succeed, and I think I am in a position to state, from what has been done at Woolwich, that they never can succeed. Colonel St. George has had four guns completed; but he not only hooped them so as to secure them laterally, but the hooping went round the back, so as to prevent the breech blow-

ing out. All four guns burst, and, if gentlemen would only take the trouble of going to Woolwich to see what has been done, they will find there these and other hooped burst guns, all marked with the names of the inventors. There is a very large family of burst guns of Sir William Armstrong—I do not speak of the coil guns, but of the cast-iron hooped guns and the shunt guns—and there is the gun of almost every inventor there, but more particularly the cast-iron hooped gun. I was present the day the Walker gun burst. I believe it stood 76 rounds with increasing charges. Perhaps it will be as well to state what that is. It is first of all fired 10 rounds with the service charge and 1 shot, 10 rounds with 2 shots, 10 rounds with 3 shots, 10 rounds with 4 shots, and so on up to 10 rounds with 10 shots, and I believe the Walker gun then stood 76 or 77 rounds without any hooping or strengthening at all. None of the guns strengthened by Colonel St. George, I was told, stood anything like the 76 rounds. I may perhaps also state, what many gentlemen here do not know, that in all these trials, at every tenth round, a gutta-percha impression is taken of the interior of the gun, and in all cases, as well hooped as not hooped, there was an invariable tendency to begin to crack at the vent. Since a cast-iron gun begins to crack in the bore without reference to the external portion—and it is only a question of time—those cracks continually extend, and it seems utterly absurd to put the hooping outside where it does not stop it. It appears to me impossible that the hooping can do any good. I am aware of the two plans of Mr. Lancaster and Captain Caffin. They were hooped all over; they were very thick indeed, and they all went at much less than the cast-iron guns without any hooping at all. If that be the case,—and the Ordnance Select Committee have got all these facts,—there is no longer guess-work and moonshine at Woolwich as there used to be; there is a record kept of every shot, the ranges and charge of powder, and every particular; I do not know to what extent the facts are published, but I have never had any difficulty in obtaining the information when it has been asked for in a fair spirit, and I presume any gentleman in the services can get this information. Here is a plaster cast of the vent of a gun; you see the cracks.

I would now allude more particularly to Captain Fishbourne's remark in reference to what he deemed service guns, and the mode of rifling best adapted to those guns. Mr. Lancaster told us generally that there were several competitors, and he did not like to mention names, the sum and substance being—I may state the fact—that his gun stood the 1,000 rounds for the simple reason that it has been fired first, and there has been no time for the others to be fired yet. Mr. Britten's has been fired 800 rounds, mine has not been fired. It takes a long time to get all these things done, and I may state, to satisfy Mr. Clay, that he is not the only person who has burnt so much powder, that even that gun of Mr. Lancaster has burnt a thousand pounds of powder and sent out an extraordinary quantity of shot.

My attention has been turned into quite another channel. Captain Blakely and many other gentlemen here, seem to have taken it for granted that it is a question of cast-iron guns or wrought-iron guns. I do not think so Many gentlemen here probably have heard of Mr. Robert Mushet, of Coleford, in the Forest of Dean, who is perhaps one of the greatest mineralogists and experimental chemists in England. For many years I have represented him in London, and when I was here last, I could only allude to what I hoped to perform. I will now state facts which I believe will go further than my opinion or the opinion of anybody else in proof of what has been done. In the first place, here is a mere cast bar of Mushet's metal (pointing to one on the table). A piece was planed out, and that piece so planed out was sent to Woolwich to Mr. Anderson to test it. I will read what Mr. Anderson said of it:—"Mr. Anderson presents his compliments to Mr. Haddan, and begs to inform him that the strength of the material tested is as follows:—1st specimen, 48 tons 16 cwt., 18 lbs. per inch; 2nd specimen, 46 tons 1 cwt. 1 qr., 13 lbs. per inch." I will now give from the same authority what the strength is of the wrought iron of which the wrought-iron guns are made—"Bowling Iron Company, 24 tons per square inch; Taylor and Company, 25 tons per square inch; best Swedish, 23 tons per square inch; Brown and Hughes, 23 tons per square inch; Blaenavon Company, 23 tons per square inch." The inference was, therefore, that if we could make a gun to bear the same tensile strength that this bar did, that there was an end of all hooping, coiling, forging, or anything of the sort. It will put an end to the question, because I presume everybody will admit, that if you can cast a gun that will stand a greater tensile strain in the proportions of two to one over any other guns, it must be better than any hooping under the sun, provided the gun will only stand. Since then, Mr. Wm. Fairbairn has made a series of experiments,

and has arrived at this result: one specimen stood 62 tons to the square inch, another specimen stood 66 tons to the square inch; another specimen stood 71 tons; another specimen stood 59 tons; and so on, the average being some 61 or 62 tons to the square inch.

Colonel WILFORD: Is that the measure of the resisting power of a gun?

Mr. HADDAN: Yes; I am coming to that. The Ordnance Select Committee, I think, took a very proper precaution, and said, "That is all very well theoretically. We dare say it is so, but we do not believe anything that we do not see. We should like to have a gun sent to try, and then we shall know what it really is." The consequence was, a gun was sent in eighteen months ago, it was bored in the Arsenal, and that was tested with the endurance round. I will read you the test; it is very short:—

REPORT of EXPERIMENT carried on in the BURSTING CELL, 23rd January, 1861.

*Object.*—To test the power of endurance of a 6-cwt. gun made of Mushet's iron.

| Nature. | No. | Weight. | Length. | Calibre. |
|---|---|---|---|---|
| .. | .. | Cwt. qrs. lbs.<br>6 2 8 | Ft. In.<br>5 10⅛ | 3 inches. |

The following Table shows the results:—

| Date. | No. of Rounds. | Cartridge. | | Wads. | Cylinders. | | Remarks. |
|---|---|---|---|---|---|---|---|
| | | Length | Weight | | Length. | Weight. | |
| | 10 | | | | Inches.<br>4 | lbs. ozs.<br>6 8 | |
| | 10 | | | | 5⅛ | 10 5 | |
| | 10 | | | | 8 | 13 12½ | |
| | 10 | | | | 10 | 17 5 | |
| | 10 | 4⅞ | 1⅛ | 1 | 12 | 20 10 | |
| | 10 | | | | 14 | 24 1 | |
| | 10 | | | | 16 | 27 8 | |
| | 10 | | | | 17⅞ | 30 15 | |
| | 10 | | | | 20⅛ | 34 6 | |

An impression of the vent taken at the 90th round, shows a slight wearing of the bottom, but no indication of fissures.

Supposing, therefore, large guns can be made, you may load them to the muzzle. I have never heard any authority give any pressure higher than 25 tons to the square inch. I suppose 25 is the highest you can get. If we can really get to 60 or 70 tons to a

square inch it is quite evident you can get the gun that will never burst. There is a gun in the Institution that is made of this metal simply cast, without any forging, tilting, or hammering, but simply cast, and the gun tested at Woolwich was also cast, and was delivered rough, so that there might be no doubt on that point. The Government asked if we would deliver a 25-pounder gun. We did so, and that that might be tried in comparison with Sir William Armstrong's gun, it is turned externally to look exactly like it. It is rifled in the same way and fired with the same projectiles. That has hitherto stood the ordinary double-proof charges, and it is now waiting the endurance charge. The next step, I presume, will be to ask for a 40-pounder, and possibly a 70-pounder; and the only question will be when the ultimate results will come, because all these things take a long time to do. These guns will be very cheap, because this metal is not half the price of brass. It is a mere question of the construction whether it is to be a breech-loader, a muzzle-loader, or on any other plan you like, and by that means, supposing we can get that strength, we can then fire an elongated shot, I am quite certain, at the same initial velocity as you now get from the round shot. Mr. Lancaster and Sir William Armstrong both seem to conclude that to get the same initial velocity with elongated shot that is got from spherical shot, requires a charge of about one-fourth of the weight of the shot. I apprehend therefore Mr. Lancaster can never dream of using the service gun rifled, since in all the experiments he talked of the charge was less than one-eighth.

Mr. Bashley Britten: At this late hour of the evening, I will endeavour to make my remarks as brief as possible. Having been engaged for many years past in making experiments with rifled cast-iron guns, the only kind of guns which I have had opportunities of experimenting with, I will just give you the results of these experiments.

In the first instance, however, I will show the nature of my projectiles. This diagram will exemplify it (Plate II. figs. 19, 20, 21, 22.) Fig. 19 shows a cast-iron shell. At the base of the shell I put a casing of lead. On the explosion of the powder the lead becomes driven up as a wedge, expands and fills up the bore, and finds its way into the rifle; and the rifling acting upon the lead gives it the desired rotation. The same principle is shown in fig. 20, a shell capable of firing molten iron. Fig. 21 is a segmental shell, and fig. 22 a solid shot. This is what I claim to be my principle for the purpose of obtaining rotation. This is the wedge. If I increase the lead wedge more, if I make the base of the wedge greater than I have shown it, the effect of it is that I get a greater area of base of wedge. The wedge is tightened up by the action of the powder to a great extent; whereas, if I keep to the point sufficient to give expansion to fill the gun, the remainder of the shot receives the powder on the base. It is not bound to tighten the shot; and by cutting this off just at the point I get sufficient expansion. All the rest of the powder goes to expel the shot, not to tighten the shot up in the gun. That is a very important point, because I find that by merely placing the width of this wedge the one-eighth of an inch the resistance becomes so much greater that it loses considerably in range and increases the recoil.

I will simply state that I have tried seven guns with projectiles of that nature. There were two 9-pounders that were fired in 1855. There was a 32-pounder 56-cwt. fired in 1856; from that gun I have fired 300 rounds. From another 32-pounder 58-cwt., in 1860, nearly 900 rounds have been fired; and from a 68-pounder 95 cwt. 300 rounds have been fired. Not one has yet been injured.

Lately, some interesting experiments have been made for the purpose of ascertaining what margin of strength there is in the guns beyond that at which I taxed them. They were put into the bursting cell. The same charge of powder that I have been in the habit of using was used. I fired from the 32-pounder ten rounds of 48 lb. service shot; ten rounds of 72 lb. shot; ten rounds of 96 lb. shot, when the gun was not injured. From another 32-pounder gun I fired the same series of shot, and then went on with ten rounds of 120 lb. shot; ten rounds of 144 lb. shot; and the gun burst at the fourth round of the 168 lb. shot. A 68-pounder was then tried, firing ten rounds of 90 lbs.; ten rounds of 135 lbs.; ten rounds of 180 lbs.; ten rounds of 225lbs.; ten rounds of 270 lbs; and ten rounds of 315lbs. with the proposed service charge of 7½ lbs. of powder, and then burst.

It seems to me that in the question that has been discussed this evening, reference has always been made to the quantity of powder rather than to the effect of that powder upon the shot. Now, I think that is hardly a fair way of measuring the

efficiency of a gun, by judging of the quantity you can put into that gun. The question should rather be, which is the best gun that, with the smallest charge of powder, gives the highest initial velocity to the shot? The accompanying figure (A) represents the space occupied by the charge in the bore of the 40-pounder Armstrong gun. I believe the cartridges are 12 inches long. Figure (B) represents the bore of my 32-pounder gun, firing a 50lb. shell, which is the nearest comparison I can make to the Armstrong 40-pounder. The charge in that is one-eighth the weight of the projectile, 5 lbs. of powder. The charge in mine is 5 lbs. of powder, one-tenth the weight of the projectile. Yet, from some cause or other, the initial velocity which I get with this 5 lbs. of powder, distributed in the bore in the way I have explained, is, I believe, considerably more than the initial velocity obtained with the same charge of powder distributed in the bore in the long form. That, I believe, is a very important point.

## EFFECT OF EQUAL CHARGES IN LARGE AND SMALL BORES.

(A.) ARMSTRONG 40-POUNDER.

| | | |
|---|---|---|
| Charge . . . 5lbs. | Bore . . . 4" | Pressure on shot 163 tons |
| ←12 inches.→ | Area . . . 12·5 | Ditto on gun 1964 „ |
| | Initial velocity 1200 | Shot, 40lbs. |

(B.) BRITTEN'S 50-POUNDER. RIFLED 32-POUNDER SERVICE.

| | | |
|---|---|---|
| | | Tons. |
| Charge 5lbs. | Bore . . . . 6·375 | Pressure on shot . . . . 415 |
| ←4⅜in.→ | Area . . . . 31·9 | Ditto on sides of gun . 1204 |
| | Initial velocity . 1209·2 | Shot, 50lbs. |

Pressure assumed 13 tons per inch.

Sir WILLIAM ARMSTRONG: You had better state the initial velocities.

Mr. BASHLEY BRITTEN: Perhaps you will be kind enough to tell me, Sir William, whether I am right in stating that the initial velocity of the 40-pounder is about 1,100 feet per second?

Sir WILLIAM ARMSTRONG: Oh, dear, no! It is more than that; it is over 1,200 feet.

Mr. BASHLEY BRITTEN: Is it over 1,200 feet?

Sir WILLIAM ARMSTRONG: I should say 1,200 feet on the average.

Mr. BASHLEY BRITTEN: Then the initial velocity of mine is 1,209$\frac{2}{10}$ feet per second. I think it is an important thing, because in the one case we have one-tenth the weight of the projectile, and in the other we have one-eighth the weight of the projectile.

Sir WILLIAM ARMSTRONG: It is a larger bore.

Mr. BASHLEY BRITTEN: It is a larger bore.

That is what I am coming to: that we lose something by the use of the small bore. I have always been using large-bore guns. It seems to me a retrograde step to use small-bore guns. For this reason: you do not use the initial force of the powder to the same advantage with a small bore as you do with a large bore. At all events there is the fact, that with one-tenth the weight of the projectile from my cast-iron guns,

the expense of rifling which is 17*s.* 6*d.* each, that gun has an initial velocity of 1,209⅞ feet, whereas the initial velocity of the Armstrong 100-pounder is only just the same. Therefore, if initial velocity be the measure of effectiveness of a gun, I would put it whether the old cast-iron gun, with this very small charge of powder, is not equal to the Armstrong gun, the initial velocity being the same. That seems a very important question.

Colonel Wilford: What is the weight and shape of your projectile?

Mr. Bashley Britten: This is one of the shot that was fired a long time ago. [Pointing to one on the table.] The shot is not similar in form now; I have improved upon it. It is now a lead-coated projectile. The lead is attached by means by which it can be so firmly united to the iron that it never separates—a plan that has been adopted by the Government for coating the whole of the Armstrong shell and shot in Woolwich Arsenal, and for which I have received some reward.

Colonel Wilford: The gun is rifled?

Mr. Bashley Britten: The gun is rifled. The grooves are extremely shallow, being ·08 in depth. Having been confined hitherto to the use of cast-iron weak guns, and having succeeded in obtaining that high initial velocity which is equal to the initial velocity Sir William Armstrong obtains with his enormously strong guns, I thought it only fair that I should be allowed to compete with him on equal terms; therefore, I have applied to the War Office for a nine-inch gun to be made on that very beautiful principle which Sir William Armstrong has introduced, being, as I believe, the only means of making extremely strong guns now. The gun I have proposed should weigh six tons, be nine inches bore, and ten feet long. I have proposed it as a broadside gun for the navy. I think that gun can be fired with 17 lbs. of powder as a rifled gun, and with 24 lbs. of powder, as a smooth-bore gun, to fire shot; and the grooves being so extremely shallow, there would be only a very small escape of windage, compensated for by a trifling increase in the charge of powder, without increasing the strain upon the gun. Although that might not in itself be sufficient to penetrate the very thick plates which it is proposed to put on ships, it is a question whether as a broadside gun the concentrated fire of three or four such guns, would not produce more effect than a single shot from a still larger gun. I have proposed that for a broadside gun. Whether the gun will be made, is a question under consideration.

There is one point to be considered besides. In all my experiments in which it has been shown I have obtained this high initial velocity, I have not increased the recoil of the gun. The principle I have gone upon is this. I did not know the strength of the cast-iron gun; I did not want to tax it too much; therefore I thought, if I kept within the usual amount of recoil, that I was not increasing the strain beyond what the gun would bear. Therefore, if these experiments of mine show that we can produce a cast-iron gun with the same initial velocity as the Armstrong gun, and the same range up to 23 deg. and 24 deg. of elevation—and up to that elevation itself the trajectory is as flat as that of Sir William Armstrong's—it is clear there must be something in this principle which I think fairly justifies me in asking to have these guns tested against Sir William Armstrong's; not cast-iron guns against wrought-iron guns; but wrought-iron guns against wrought-iron guns.

A gentleman said just now you could not use rifled guns of more than a certain weight in consequence of the excessive recoil. Now, in these experiments of mine, in which I have got these long ranges and these high velocities, the recoil has been less than the recoils of the same guns with the old service charge. In fact, I have regulated my charges by that means. So long as I did not increase the recoil beyond what is the usual amount of recoil, I thought I was safe, and it has been shown I have not burst a single cast-iron service gun. They have stood, not one has failed, and I have tried seven of them.

Whether these cast-iron guns are capable of being rifled is still under consideration; I think the Committee are pretty nearly in a position to come to some definite conclusion on the subject.

The discussion was adjourned till the following evening.

## ADJOURNED DISCUSSION.

Wednesday Evening, May 21.

### W. Stirling Lacon, Esq., in the Chair.

Mr. Michael Scott, C.E.: I shall be very glad to submit a few observations; but it will be with a good deal of diffidence in the presence of such an audience, inasmuch as I am not professionally connected with this subject. To me, Sir, it is a matter of purely scientific interest, and I shall make my observations as brief as possible, especially after the intimation which we have received from you.

In the first place, I would wish to say a few words upon the subject of breech-loading guns. We all admire the great ingenuity displayed by Sir William Armstrong in constructing his gun, but I think in the case of the large-bore naval gun, breech-loading is a mistake. I was puzzled for a long time to guess at the supposed advantages of breech-loading; but, as they were stated by Sir William Armstrong at the last meeting, we can have no longer any hesitation upon the point. The first advantage he stated was, that the men who were working the gun were not so much exposed. That is a point which must be left to naval officers to discuss; it is one which I cannot touch, and do not profess to have any knowledge upon; but I hope, as there are several distinguished naval officers present, we shall have some information upon it. The second advantage stated by Sir William Armstrong was, that a longer gun might be employed in narrow ships. Now it appears to me that the gun which will be required to deal with these iron-plated ships, will necessarily have a very great recoil. If the shot has a high velocity and is of considerable weight, the recoil of the gun must necessarily be great; and therefore the advantage that might have been claimed on this ground for the guns hitherto used in the naval service, may not be so apparent in the new guns that will require to be constructed to deal with the iron-plated ships. I will subsequently submit to the meeting a table which will show the amount of recoil that must necessarily follow the momentum that is communicated to the shot, if that shot is to have any effect upon the iron-plated vessels. The disadvantages of breech-loading, I think, are very apparent, when it is applied to large guns. In the first place, they are weak—I think necessarily and essentially weak. The answer to that may be—I think it was stated by a gentleman at one of the previous meetings—that the guns that have been constructed, are strong enough to bear the strain that they have been subjected to, and therefore there is an end of the question. But I think it is hardly the end of the question. A seven-inch gun made of wrought-iron has been found strong enough; but it follows, that if that gun of seven inches in diameter is strong enough as a breech-loader, a gun ten inches in diameter as a muzzle-loader would be as strong. If, therefore, it be an advantage to have the large guns, I certainly think that the muzzle-loader would have the advantage in the matter of strength. The case is very much this. In the case of the muzzle-loader, it may be considered, that the strain is applied in the middle of a tube, to burst it; in the case of a breech-loader it is applied at the end. It appears to me, therefore, to be very clear that the muzzle-loader having a closed end must have at least double the strength of the breech-loader having an open end. The fact of their being weak involves a small diameter; and, if breech-loaders are not weak, it is a very remarkable fact that we have not a gun of large diameter, a breech-loader. I do not know of anything above seven inches. If breech-loaders are equally strong, why not have them of larger diameter? In the case of the last gun that has been tested, so far as I know that gun, it was ten inches or ten inches and a half in diameter. It was not a breech-loader; it was a muzzle-loader. I am not aware that Sir William Armstrong has ever applied breech-loading to a gun above seven inches in diameter. If the guns are small in diameter, it follows that the capacity of the shell is small, and that the weight of the shot must be comparatively little. Further, the initial velocity is low. Now, if those guns made by Sir William Armstrong are of such vast strength, why not increase that initial velocity? Naval men tell us they want that velocity, and we know that the destructive power of the shot is as the square of the velocity; therefore velocity is a very important matter. But it appears from what Sir William Armstrong said on the last occasion, that the velocity from his gun is 1,210 as against the velocity of the ordinary 68-pounders, which is 1,580;

and, although Sir William Armstrong has a shot weighing 110lbs., he shows by his own figures that the relative effect of these shots from the 68-pounder is 17, and of his shot, on account of the lower velocity, although it has a much greater weight, only 16. Now this velocity is wanted, urgently wanted. If there is any hope of penetrating the plate, it must be by velocity; and the power of the shot increases directly, not as the weight, but as the square of the velocity. If it can be obtained, it is very desirable; but it has not apparently yet been obtained by any breech-loading gun. If the initial velocity is low, as I have just said, the force of the blow and the penetrating power of the shot must be small, and it would appear from the figures supplied by Sir William Armstrong on the last occasion, which are still on the board, that the penetrating power, the *vis viva*, the living energy of the shot, of the 110-pounder (I speak, of course, of close quarters, at the muzzle of the gun—I am not referring to long ranges at present) is only 16, as against the old 68-pounder spherical shot 17. In addition to this, there is in the Armstrong gun a great complication of parts, which are liable to injury. They are expensive; and if we compared the effect produced with the cost, the effect being less of the 68-pounder, I believe the immoderate expense would be very obvious. I do not know that it is desirable to say anything more upon this branch of the subject.

I shall confine myself to a very few remarks upon the shot and gun best adapted for dealing with plated ships. Spherical shot indents the plate; and the shot, if of cast-iron, breaks. Now, if it is desired that the shot should penetrate a plate, I say that the whole power absorbed in the indentation, in the bending of the plate, and the breaking of the shot, is lost. Flat-headed shot would neither indent nor draw the plate; and it has this advantage, that the impact being distributed over the whole of the surface, instead of being concentrated on a point, and at the same time—the impact taking place in the direction in which the shot is strongest—that is, vertically in relation to the surface, if it is intended to penetrate the plate, the flat-headed shot would unquestionably have the advantage. It might be objected that the flat-headed shot would meet with greater resistance from the air. Now this is a point of considerable interest; and it has been examined by a gentleman of the highest scientific qualifications, Mr. Froude.

Admiral HALSTED: I shall be happy to place at your disposal a reality, instead of the supposition you are giving us. Here is the actual measured plan of the effects of firing the 156-pounder shot on the Warrior target, on the 8th of April last.

Mr. M. SCOTT: I have not had an opportunity of consulting that.

Admiral HALSTED: Of course you have not; but I mean to say that what you are putting before us is a supposititious case, and you are perfectly welcome to use that diagram, for that is a reality.

Mr. M. SCOTT: I am very much indebted to you, Sir, but it would be difficult for me to examine it. It would be difficult for me to digest this diagram at the present moment. As I stated at first, my interest and connection with the subject is purely scientific. I am reasoning the matter from first principles. I know nothing about the experiments that have been made by the Government, and I do not profess to be able to say anything about them; I merely submit my views for what they are worth. Mr. Froude has shown that the resistance in the direction of motion to a plane moving obliquely is the same as the resistance to the plane at right angles with the line of motion, which is subtended by the oblique plane if the angle of obliquity is not less than about 60 deg. If so, we have then the condition of a pointed shot, as compared with a flat-ended shot. It would therefore appear that the resistance due to the pointed shot is the same as, and no less, up to the limit of 60 degrees, than the resistance of the flat-ended shot. That seems to be proved. I confess that I can see no error, nor has any one else that I know been able to see any error, in that conclusion. In the case of spherical shot, it may be argued in their favour, that, supposing they do not penetrate the plate, at all events the whole of the power of the shot is expended on the plate, whereas the flat-ended shot may go through and have a considerable power left, and, if it has no work to do inside the plate, that power will be lost; but in the case of shells, I apprehend, no influence will be produced, unless it does penetrate the plate. Therefore it would be desirable that they should be made flat. Now, I have been always told that, in the case of those partially plated ships, the ordinary spherical shell will not penetrate even the thin plate, and that, therefore, all they have got to fear is solid shot. But I can easily conceive that a flat-ended shell might be able to penetrate the thin plate, and might have very great destructive power when it had passed through that plate.

I will not detain you longer, Sir, upon that point, and I fear that perhaps I have

detained you too long; but I wish to say a few words upon the subject of the size of gun that can be obtained for naval purposes, and to deal with iron-plated ships. Now, to penetrate a 4½-inch plate, for instance, requires necessarily great force of shot. That force is made up of weight and velocity; and the limit of the force of the shot is the strength of the gun, which of course is determined by the strength of the material. Assume, for the purposes of argument, that the material is wrought iron, and that this material is three times stronger than cast iron; and assume that the strain of the cast iron is equal to that of the iron in the 68-pounder; then, I think, it can be determined theoretically what would be the bore of the guns for different weights and velocities of shot; and I have constructed a table for the purpose of illustrating this. The accompanying table shows the weight of shot which may be fired from wrought-iron smooth-bored guns, of various sizes and with various velocities, without straining the metal more than the metal of guns in the service is already strained. The type of the service gun I have taken is a 68-pounder.

| Bore of Gun. | Weight of Shot for velocity of | | | Weight of Sphere. | Weight of Elongated Shot. | Velocity of Elongated Shot. | Force of Blow of Elongated Shot. | Momentum of Recoil from Elongated Shot (Col. 6). | Weight of Gun, to give same Extent of Recoil. |
|---|---|---|---|---|---|---|---|---|---|
| | feet. 2000 | feet. 1750 | feet. 1100 | | | | | | |
| inches. | Ordinary 68-pounder. | | | lbs. | lbs. | feet. | | | tons. |
| 6 | | | | 70 | .. | 1600 | 1·0 | 1·0 | 5·0 |
| | lbs. | lbs. | lbs. | | | | | | |
| 7 | 118 | 154 | 390 | 47 | 93 | 2253 | 2·64 | 1·87 | 9·35 |
| 8 | 135 | 176 | 446 | 70 | 140 | 1964 | 3·02 | 2.46 | 12·30 |
| 9 | 152 | 198 | 502 | 100 | 202 | 1734 | 3·40 | 3·13 | 15·65 |
| 10 | 168 | 220 | 555 | 131 | 273 | 1565 | 3·75 | 3·82 | 19·10 |
| 11 | 185 | 242 | 611 | 174 | 366 | 1422 | 4·13 | 4·65 | 23·25 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

Column 1 gives the bore of the gun in inches; column 2 gives the weight of the shot which may be fired with a velocity of 2,000 feet per second; column 3 gives the weight of the shot which may be fired at the velocity of 1,750 feet per second; and column 4 gives the weight of the shot which may be fired at the velocity of 1,100 feet per second. The next column gives the weight of a sphere of the diameter stated in the first column; the next is the weight of an elongated shot of two diameters length, but not solid, hollow behind; the next gives the velocity of that elongated shot; and the next gives the force of the blow, that of the 68-pounder ball, taken at 70 pounds in round numbers, moving at 1,600 feet per second, being taken as one. The principle upon which this table is calculated is very simple; but it involves a great number of figures. I have stated publicly on previous occasions, and I do not know that it has ever been disputed, at all events I place in the hands of the Secretary of the Institution the details of it. I do not know that it can be disputed, because there does not seem to be any dispute whatever with respect to the theory, namely, that the power of the shot is the *vis viva* of the shot, the living energy, the weight multiplied by the square of the velocity. If that be so, then the only other element is the diameter of the gun. The

force of the blow, you will observe in column 8—and it is somewhat important—varies very considerably. The argument is this—assuming wrought-iron, in the first place, and assuming that wrought-iron is three times as strong as cast-iron, that without straining the metal of the gun more than the metal of an ordinary 68-pounder is strained by firing a 70 lb. shot at 1,600 feet per second, this is the effect. These numbers represent the force of the blow, or the effect produced by the shot from these varieties of gun.

A MEMBER: May I ask, what charge?

Mr. M. SCOTT: It is quite irrespective of charge. The question has nothing to do with the quantity of powder. It is a relative question—not an absolute. I do not profess to give the absolute effect; I do not know that it is possible; at all events, as far as I am concerned, I do not profess to deal with it at all. If you fire a 68lb. ball at the velocity of 1,600 feet per second, that is represented in this table by the figure as 1; and, if you fire any of those other weights at those other velocities stated in the table, the *vis viva*, the force, the destructive energy of the shot, will be as represented in this column, without reference to what the powder may be. It may require one pound or a thousand pounds of gunpowder; it does not affect the relative question. It affects the absolute question, no doubt; but the relative question is not affected, and the table is merely a relative table, to show what the effect of various diameters of guns and various weights of shot would be. From this table it appears—and it is a somewhat curious result—that for a given bore of gun, whatever be the weight and velocity of the shot, provided these vary in such relations as to keep the strain on the gun the same, the destructive power of the shot always remains the same. I think that is a point of some importance, and I am not aware that it has ever been stated before. I think important results will flow from it. For example, one conclusion would be this—that a light shell, provided the material of the shell was strong enough to bear the impact, would penetrate at very close quarters, because all these calculations have reference to the velocity at the muzzle of the gun—would penetrate equally with a heavy shot.

A MEMBER: If it did not break up.

Mr. M. SCOTT: Assuming that the material of the shell bore the impact as I say, provided it did not break up, the light shell, having the higher velocity, would penetrate quite as readily as the heavy shot with a low velocity; and it would appear from that table, that this is a fixed quantity, an unalterable quantity, provided the strain of the gun remain the same. In reference to any given diameter, you have the figures, which show that, no matter how you vary the weight and the velocity, the effect at the muzzle of the gun must be the same. Without detaining you, however, any further upon this point, I would just say a few words upon the recoil of guns. That is a point, surely, that is practical, and surely it is interesting. The ninth column of the table represents the recoil for the elongated shot in column 6, and the velocity is in column 7. The column marked 10 gives the weight of gun to give the same extent of recoil as an ordinary 68-pounder; provided the resistance, the compressors, and other artificial means, be increased in proportion to the weight of the gun. I think it is a practical question for the naval officers present to determine, whether they can deal with guns of 12, 15, 19, and 23 tons. If they cannot, it necessarily and inevitably follows that they must expect a greatly increased recoil—increased in velocity, and increased in distance. As for example: suppose you take the 9-inch gun, the weight of which, to give the same recoil as the 68-pounder, would be 15¼ tons. If that be found inconvenient, possibly it might be diminished; and, suppose that the weight be diminished to one-half, the distance of recoil will be increased four times. If you diminish the weight of that gun to one-half—suppose you make it between 7 and 8 tons—the velocity of the recoil will be doubled, and the distance of that recoil will be four-fold. If, therefore, the recoil of an ordinary 68-pounder is 8 feet, the distance to which that gun would recoil would be 32 feet. That, I say, appears to me to be a matter of considerable practical importance, and one that would be very well worth the consideration of the naval officers present.

Gentlemen, I will not detain you longer; I will merely say this—that, although these statements do not appear, perhaps, at first sight, to be what you may call practical statements, that is, that they are not the result of absolute experiments with individual guns, there is not the slightest doubt about the principle. It is not to be disputed, and, therefore, it must have a very considerable bearing on the practice.

Commander ROBERT SCOTT, R.N.: In following those who gave you such very well-digested speeches on the merits of their own plans last night, I am placed at great disadvantage, for it was not my intention to have compared my own propositions with those

of others, except in a very general manner, having already given publicity to them here, as elsewhere; and I am strengthened in this view by the able discussion of them by Captain Fishbourne, and I remember, also, the old proverb, "Let another praise thee, and not thine own self." I should, however, be admitting the correctness of what has been here asserted, did I not oppose facts to those assertions; and, therefore, with your permission, I will examine a little more closely into what Mr. Lancaster stated last night; as, if correct, the rifle question is certainly settled in favour of the oval; the exterior of the lead, he said, gave off in fumes, and the grooves, at any rate—pointing to mine—the grooves, he said, crush up, and, as grooves crush up and lead evaporates, the only remaining plan is the oval. I trust, however, to convince you that Mr. Lancaster is quite as much beyond the mark in what he mentioned last night—I am sorry to mention names, but, the comparison having been made, I am of necessity forced into it. I cannot help it, and I hope you will see that; because, if my groove crushes up, what is the use of my gun? It is evidently a useless thing, and all that has been advanced is mere moonshine. However, as I have said, Mr. Lancaster is quite as much beyond the mark as he was when he wrote to the *Times*, and mentioned that his own gun had fired 284 rounds, which I know that he afterwards admitted not to be correct. Again, Mr. Lancaster said in this very letter, that Mr. Jeffrey's shot and my own were forced home by a heavy metal rammer, the same which had to be applied after double sponging, in order to force home each of his shells which had been carefully turned to one exact windage. In my own letter in reply to that, which also appeared in the *Times*, I said, that, if the heavy metal rammer had to be used in practice-ground under such circumstances, it certainly would condemn any such gun for naval purposes *in toto*, but it was not used with my gun. And I will ask this, and there are several naval officers here, who, as well as myself, have seen the oval gun fired, for I was at Shoeburyness in 1854, and was sent purposely there. I need not read my own notes on the subject; I shall be very happy to let any of those officers see them, and my report to the then Controller. We have seen the gun, and we know exactly what it has done; and, had the oval been a good gun, should we have thrown it aside altogether? or would they in the Crimea, when it was of such consequence to fire a shell with a large bursting charge, have entirely given up the oval, and continued to fire the round ball, which, of course, had a short and unequal range from the gun? I leave it to yourselves to judge whether such would be the case. However, it would be beside the mark did I give all my objections to the competitive trial, prior to which my gun had fired so many more rounds than Mr. Lancaster's and others, excepting Mr. Bashley Britten's (I am not going to touch on Mr. Britten's gun), and completed them within a much less time. My gun had been bored, rifled, and fired up to 300 rounds, as fast as the shell could be recovered, and the days afforded to me to carry out the experiment at Shoeburyness, would allow. It certainly never entered into my head, on the score of injury to the rifling, to object to the competitive trial, although my gun had previously fired 300 rounds, for at their conclusion the assistant superintendent, with myself, examined the gun most carefully, and we could not see a line in the gun worn down, and he said to me, "The bore appears quite perfect." But are there any other indications? Yes, when the shot were fired rough at first, and not smoothed off as I fired them there, and a soft metal put outside, the same soft metal that Sir William Armstrong afterwards used in solid strips (or even perhaps before, but I think it was afterwards) I put on liquid zinc, forming a beautiful coating, placing a soft metal in front of a hard bearing, which could not possibly give way. But, before that was done, the paint of my shell was really merely smoothed down after firing. It seemed so extraordinary a fact, that when it was mentioned to Captain Blakely, and also to Mr. Lynall Thomas, both these gentlemen inquired into, and examined the case for themselves; and so did the Admiralty. But is that all? Certainly not; fifty shells completed 300 rounds. There were some few new shells introduced, with which I tried an experiment, which is not worth while going into here, but about forty-six of these shells were recovered off the range and re-fired. That is how the 300 rounds were made up. The Report states that not one of these shells was cracked, and the assistant superintendent said to me, "I consider the shells are still serviceable." One of these shells is now in the Exhibition. If the bearings of the shells had been scored, or if there had been rubbing or crushing, it would certainly have shown itself upon them; but as nothing of the kind took place, and as I made some objections to the Committee's trial, I should certainly have objected *in toto* if I could have detected the least irregularity upon the line of my rifling; but such was not the case. As far as human eye could judge, and I examined the gun several times with those at Shoeburyness, it seemed perfect.

But, as the gun has been compared with his by Mr. Lancaster, that is not the only point

in which it should be compared. The shells were all easily loaded, as I have now said; but what took place as to the other shell of the oval with which my gun has been compared? The first shell that was fired in this competitive trial went out of the gun broken up. A per-centage of those that were picked up, seen by Mr. Haddan as well as myself —who can say whether it is the case or not—I have not spoken to him on the subject, but he happened to pass as I was examining the heap to look for my own shot—a considerable per-centage of these shells were cracked also. The reason of that cracking is obvious. Suppose you take a flatter groove—my groove (Plate I. fig. 8 *g*)—the shell of course has a bearing upon that groove, and comes out in consequence easier. But cut away that groove, and bring it round and make it into an oval, there is then no bearing, and, unless the shot is exceedingly tight, you can see there must be considerable play. Now, the gun turns the shot, and the shot has to come out grinding against the bore, and I ask any one who understands what friction is, whether there is most friction with the plain or flat bearing, or with the oval bearing, and a shot that wedges itself round against the side of the bore?

Not only so, but I think it is apparent to everybody, that, under most cases, such a wedging open would be much more liable to burst a gun than grooves such as I propose. The strength of cast-iron guns is very unequal; were the cast-iron equal we should have fewer cases of bursting; but I think most of us know of many cases of bursting that have occurred. When I was at Shoeburyness a gun burst and it broke the legs of three serjeants; it was a gun of the oval bore.* We know that three Lancasters burst in the Crimea, and therefore, speaking of bursting, we are pretty much—as Mr. Haddan expressed it—"in the same box, the whole of us."

Experiments have been put forward, and they may be again put forward, as indicating the relative value of different systems of rifling, and therefore it is really important to examine into what has been tried. There happened to have been competing together the shunt of Sir William Armstrong and my own gun with grooves, Mr. Haddan's also with grooves, (though shallower and swept out more), and, on the other hand, Mr. Bashley Britten's, and Mr. Jeffrey's, and the oval bore. Now this list completes the whole that were competing, and, as it takes in the whole, it is necessary to dwell a little more on this subject. I think that the endurance of one gun, does not prove much; the opinion of the President of the Select Committee certainly was in the same direction, for, when he brought forward the plan of strengthening, mentioned last night by Mr. Haddan, he at once tried it upon four guns—two sixty-eights and two thirty-twos. Could it have been settled by one gun, I imagine he would not have taken four guns for such a purpose. I think we must all admit, that we have been somewhat mistaken as to the strength of cast-iron. When 5½ pounds of powder have been fired with the lead-coated shot, the guns have gone; with 5 pounds they have stood. When over 6 pounds has been fired with the iron shot, those guns have also gone; therefore, if we are to use the unstrengthened cast-iron guns, we shall have to use a very low charge. When Mr. Whitworth's gun burst, which was a 68-pounder rifled on his plan, they asserted that the shot stuck in the bore; it was referred to Mr. Anderson, who at once said that what surprised him was, not that the gun burst, but that it stood at all.

Much has been said as respects lead-coated shot. Speaking of Sir William Armstrong's grooved gun, it is clear it is not suited to high velocities; and I think that it is shown by Sir William Armstrong himself, for he has only used the shunt with high charges of powder. The shunt has been fired with 20 pounds, but the other guns certainly will not stand large charges of powder—they cannot be fired with large charges of powder. It has been said in this Institution that a large charge of powder was used in the 110-pounder gun. Yes, but the lead in the rear is then cut away. I have examined many of the 110 lb. shells, looked at those very narrowly that have been picked up after firing, and I have observed this, that while with the longer bearing of the shell the slip upon it is very slight, with the shorter bearing of the shot of the same weight, the slip upon it is considerable. But you will ask me "How have you ascertained the slip?" I think I could show you how. The width of the groove and the width of the lands we will assume as being nearly the same. Now, the lead on the shot that has come out of the gun, if it does not slip, ought to be fully the width of the land; but instead of that, it is not. In the solid shot it is not more than half the width, and in some cases I think, it is less than half the width, almost up to a point; and any of you who will examine the shot fired, will see exactly the

* We are requested by Captain Scott to state he confounded this gun with another of Mr. Lancaster's, which burst on a different occasion, viz. on Jan. 31, 1856.—Ed.

same thing and how that is indicated, and, if you examine those fired at the butt, it is true they show the rifling, but how much that rifling has slipped round, it would be difficult to say.

However, there was another assertion made here, and I think what I have said of the shunt indicates, although Sir William Armstrong does not quite agree with it, that the detaining of the projectile is damaging; he has said it is an advantage. If detaining the projectile be an advantage, I imagine that he would not have made his last breech-loading gun a shunt. It was tried against the Thornicroft plates down at Shoeburyness. On that occasion the wedges stuck fast; afterwards in trial, on being brought back, the wedges broke, and the gun itself was returned to Elswick. It has come back, and has been housed in the arsenal store ever since.

Breech-loaders have been spoken of, and I believe Sir William has gone to the limit of size in breech-loading. In fact, he allows, as we know perfectly well, you cannot lift out the vent-pieces. One of the strongest men at Shoeburyness said to me "It is the easiest thing possible, just try, I like to convince you." I said "I am very happy to do it," and we commenced lifting out the breech-piece. But after we had lifted it out two or three times he had enough and did not wish to lift it out any more; and I can tell you we had a great deal of difficulty in dropping it down exactly in its place. And therefore, with breech-loading, the fact is, over seven inches it cannot be worked at all; you may take any breech-loader you like, I have not seen any of that size that can be worked.

It is confessed that a naval broadside-gun must fire a heavy charge, and I certainly think this element of weakness the breech-loading, should be eliminated from the gun. To pass on, however, Sir William has told us an effective broadside-gun must have a large bore, in order to have a high velocity, and this of necessity entails firing a round ball, and therefore that the new naval gun is to be a smooth-bore. If not presumptuous in one who has all his life studied the subject—because I do not come before you without having studied the subject; in 1854 I was sent to Shoeburyness in order to keep the Controller-General of the Coast Guard informed of what was going on in gunnery there, and to report to him whatever was likely to be beneficial to the navy. Mine are the ideas of a whole lifetime, and I may say I have passed years in devising and carrying out what I believe to be a very simple and easy mode of uniting the advantages of the smooth-bore and rifle in one gun. I would especially say it is very desirable to unite them, and for this reason—that we really do not know, what form the attack or defence in future warfare may assume—a point I hope very soon to hear discussed in this Institution, and I am quite sure some very valuable facts would be brought forward in relation to ship-building and other points. I hope Captain Coles, whom I see present, and whom I believe has spoken of giving us a paper, will do so on an early occasion. It is a subject of really national importance, and we shall all be delighted to hear him; on that ground there is no difference of opinion; I am sorry to say on the rifle question a very strong amount of feeling certainly does exist. The new gun that Sir William Armstrong is now manufacturing, is 106 inches long in the bore, it is 9·22 inches in diameter, it is to weigh 112 cwt.; that is the exact dimension of the gun, but I think I need not give my opinion farther respecting it. However, from such a gun, if rifled, shot whether flat or round-headed (for this must depend on the form and outside of future vessels) with a shell rear would prove very effective by bursting between the plates and backing. There are many mistaken ideas about shells. I think there are one or two experiments that Captain, or rather Admiral, Halsted has watched very narrowly. When the shell was thickened in front, it was found that it passed through a plate of three inches and did not break up—I am now speaking from memory. Captain Inglis of the Engineers gave a lecture on penetration of shot, and I would recommend all who are interested in the question to get it. There are many experiments recorded that I tried in vain to get elsewhere, and many of them are of very great value. However, with respect to that, and as illustrating in some measure what Mr. Michael Scott, whom I never had the pleasure of seeing before to-night, has stated, I believe that the same penetration which is here given, an inch and a half, was attained by the shell fired from the 68-pounder. It went with a very high velocity, and if we can give that, without over-weighting our projectile, so much the better. I do not see the necessity of what Sir William Armstrong has here said about doubling the weight of the projectile, because, in doubling the weight, of course you increase very considerably the strain upon the gun. I think you may cast your projectile considerably lighter, with a cutting flat front, and shell in the rear, which would

cut through or at least penetrate far enough to discharge its small mine, and do considerable damage inside the armour plate; I believe it will be found to be a very destructive kind of shell, and a shell we shall possibly have to use in future warfare.

A MEMBER: Are you alluding to the smooth-bore?

Commander SCOTT: I am speaking of a rifle gun; but I speak of combining the two, and I say we must have a gun of this description at once; it is no use going on as we have been. We have had one era of artillery, and we have gone on and made an immense number of guns, I believe opposed to the opinion of every naval officer who has considered the subject at all. I know it was stated at meetings nearly two years ago that we were really retrograding in going to small-bore rifled guns, and I think it is now very desirable not to take a turn in the other way, and hold on to smooth-bores entirely, but combine the two, for we do not know what future warfare may really necessitate. One of the most important things that has been very much overlooked is that of molten iron. The molten iron will fill up the shell and make it almost solid, so that you will at first have the full blow of the molten iron, and, unlike powder, the molten iron, if you can pitch it against anything, will stream over it; it may stream into the port. This will be found, I believe, a very fearfully destructive weapon. The Armstrong gun will not throw it, that is, practically it will not do it. The small round shell contains too small a quantity to be effective. What we want is a large quantity; but even the less quantity sufficed to set a vessel on fire; and when it was tried, although they had the engines and everything ready, as is well known to Admiral Halsted, they could not put the fire out.

With regard to the recoil, I believe there are very simple means of reducing it. India-rubber behind the trunnions, I think, will do it; that is, it will save the gun, by lessening the strain. Sir William Armstrong mentioned the bore of the gun being soft, and wrought-iron is very soft, and that it might be necessary to use a sabot. There was a kind of one used when we actually did fire round-ball out of my rifled gun; not that it was necessary. In that particular gun we used a small wad made by Mr. Belfield, which answers all the purposes, and can be made for about 3*d*.; but I trust we shall have a bore sufficiently hard, whether of steel or some other metal, so that we shall not require anything of the kind, and I look upon every addition as of course complicating the gun.

To return to our present cast-iron guns. Colonel Lefroy has stated, they have been long known to be improved by a reduction of windage, but they wont't stand it (these are his words). Has it ever been tried, because I can find no experiment of the kind, to make a reduction of charge equivalent to the reduced windage, because then you will have accuracy, and you also save powder. I am not aware of any experiment, either, to test the increased accuracy arising from a more exact boring of the gun. Some may not be aware, that none of our guns are truly bored, and the few that are, are the exception; the rule is they are bored roughly, and I believe it is a considerable element of error, and one that does not appear to have attracted much attention. But as the 68-pounder now stands, it is accurate, and some excellent shooting has been made with it, and, if I mistake not—in fact, I know it is the case—at 300 yards at Shoeburyness it beat the rifle guns on one occasion, though pointed by Sir William Armstrong himself. I believe where the charge is increased, the accuracy would be much more sustained; instead of stopping at 16 lbs. of powder, we could go up to 24 with our 68-pounders. Now we cannot do it with the guns in their present state, and, as the Duke of Somerset justly said, it is very desirable to do what we can with our present stores. Now Captain Blakely has proposed a plan for simply hooping. Mr. Lancaster proposes to encase the gun; and Mr. Haddan says the guns are not strengthened by either method. First, with respect to Captain Blakely's method of strengthening. Here is a trial of strengthening, by order of the Select Committee in 1835, which Captain Blakely has put into my hand, in which I find that the Blakely gun stood an immense amount more firing than any other.

A MEMBER: What size gun was it?

Commander SCOTT: I gave the size in a former lecture here.* Perhaps you will kindly look at it; my memory does not serve me. I think I ought to pause here one instant, as Captain Blakely has taken my rifling, but with my permission. I asked the

* See Lecture on Progress of Ordnance at Home, &c., p. 18, vol. VI., Journal of the Institution.—ED.

Admiralty if they had any objection to his doing it; when Captain Blakely spoke to me about the matter, and kindly offered me something, I said, "The only thing I have to say about it is, that you will please to consult me about the rifling, that I may see that it is well done." I cannot say that he has always consulted me on the subject; I believe it is, that he thinks it would put me to trouble and expense, but I should always be very glad to see him on the subject. I may mention, however, that Captain Blakely examined that gun of mine that was burst, and wrote to say that he found the rifling not at all injured. I have to stop here one instant, and I am sorry I omitted it, to speak of the endurance exhibited by the different competitive guns. Now, among the guns fired in the competition at Shoeburyness, excepting my own and Mr. Bashley Britten's, there was no gun that had fired near 300 rounds, and our guns had fired them at elevations. The guns that completed the sixty-five competitive rounds were taken from Shoeburyness, where they had been fired at elevations, mounted on their carriages, placed in the cell at Woolwich, and suspended horizontally on a swing. The consequence was, on the first impact of the charge, the gun recoiled; and my own opinion is that Mr. Lancaster's gun, if it has fired 1,000 rounds, will probably go on and fire 2,000 more; for every one knows what a different thing it is to fire a gun horizontally, and suspended where it will at once recoil, and these differences were my reasons for objecting to my gun being put into the trial. When my gun did burst, the coated shot were somewhat in favour, and iron-shot, if possible, were to be set aside. Various hypotheses were set up about the bursting; but, when the pieces of my gun were brought together, it was found there was a very bad flaw in the bore, and, when I managed to get hold of my ten shot and examined them (only ten rounds were fired in this competitive trial before my gun burst), I found the shot were scratched along their bearings, showing that the gun had been gradually opening. There was nothing but what is straightforward about the matter; there had been various theories put forward, and I have no doubt, those who advocate lead coating, as is generally the case, wish to believe what they wish to be true.

But I have wandered away, and I must apologise to you for it, from Captain Blakely's strengthening. After seeing Captain Blakely's hooping, it struck me that putting it on straight in one piece, would be better. I have not seen it; but I also know at the same time that any man would put it on in one piece, if it were not for the expense; it is more expensive to put it on in that way. Mr. Parrott, in America, I find since I gave my last lecture, says his plan differs from that of Captain Blakely, in that he puts it on in one piece, whole; and it is precisely that mode by which he gets the increased strength, and I have no hesitation myself in expressing my firm belief, that such a mode of strengthening, if the jacket is carefully put on by hydraulic pressure at a certain force, is the best, and I will give you a reason for it. In the Armstrong gun at the end, there is a large piece; it is a forged breech-piece, and I believe it is the only part of the gun which I have never seen broken. Hoops are welded immediately against this forged piece, the grain of the iron running in a different direction, and over this another coil is put. They are two different sorts of iron. If over the wrought iron the coil gives strength, why should not the coil over the cast-iron give strength, provided you regulate the tension properly? I allow in the proof in the cell, the hooping may not appear to strengthen the gun in any great degree, and for this reason, the proof in the cell consists in gradually increasing the weight of the cylinders, the first cylinder being heavier than any shot you would fire out of it.

I believe the hoops prevent the iron from disintegrating. You know the particles are merely laid together; they are in close proximity, but there is no interlacing of fibre; and the continued concussion opens them, and, if opened, any gun will go—continuous fire, is proved always to destroy the guns. I believe hoops, however, will prevent disintegration, and, if you prevent that, I have no doubt in my own mind you could make our present 68-pounder, hooped in such a way, a strong durable gun, capable of firing 24 pounds of powder.

Mr. Lancaster proposes to encase the gun, and he says that a cast-iron interior would be less liable to injury than one of wrought iron. If Mr. Lancaster proposes to apply the plan to our present guns, I believe the expense will be an insuperable objection to it, for if you cut away the trunnions—I do not enter into the question of putting the casing on, it will be rather difficult, but it is a difficulty that may be got over. I think the expense will be exceedingly great; quite half that of a good wrought-iron gun. If he intends to hoop new castings, it may be asked, would not a less brittle metal be better?

I certainly should prefer myself good wrought-iron to cast-iron, and would venture to suggest as an experiment that might be easily tried, to take one of the Armstrong guns, that have been used in proving vent-pieces, of which there are four—the coils are opens so that they are of no further use—and let it be fired at. There is the muzzle also of a good forged gun, that of Mr. Lynall Thomas, which might be fired at, and also that of a 68-pounder. Then you would come at once to the respective endurances of the three, in being fired at. But with regard to Mr. Lancaster's gun that he speaks of here, there was an endurance mentioned of 81 rounds. I am satisfied that I was not mistaken in stating that that gun was considerably heavier than the 68-pounder; and therefore it is not surprising that if the gun be very much heavier it should stand a very much larger number of rounds.

I am sorry I have taken up so much of your time, and I will conclude with only one observation about the Armstrong gun. A gentleman thought that he would investigate the matter for himself; the Captain of a man-of-war was a friend of his, he went on board, and at his request the captain sent for the gunner and the gunner's mate. There was an Armstrong gun on board, and they showed him everything about it. He took the gunner aside, and said "Tell me what is your candid opinion about it;" and says Jack "Well, Sir, my opinion is that it is a werry dangerous gun."

Admiral TAYLER, C.B.: As the time is very short, I shall only make a few observations. In fact, the very able discussion we have now had from Commander Scott, renders it totally unnecessary for me to expatiate more fully on anything that has been said, because I fully agree in everything he has stated.

I will, therefore, briefly describe to you a gun of my invention, and also a conical ball,* and I believe I was the first person who brought forward conical balls. In the year 1842 I proposed conical balls, and Admiral Sir Philip Durham wrote to Marshal Soult mentioning it to him, and, the Government having given me the permission to publish my work on Gunnery, he put the question to me, and asked me if I would show him the model. As I had permission to publish it, and of course it would be known to every one, I gave him one of the models; he was the Minister of War, and he declared that he had never seen or heard of any conical ball before; at the siege of Toulon the French invented an oblong ball, but he admitted it was tried and failed. About six months after this Colonel De Vigney took out a patent for a conical ball, because he found the conical ball was calculated for a rifle that he had invented some years previous; and it was evident the conical ball was not known in France, or the patent could not have been allowed. I forwarded this conical ball and shot to different members of the Government; they were sent down, I believe, to the "Excellent," to be tried. It was intended to be tried by an English musket, which they were made for; but I received a letter, stating that they would not try musket balls, I must send down 32-pounders. Now, I had no foundry, and, as a half-pay officer, was not at all disposed to set up one; and, therefore, they gave me the go-by, and there was an end of it. But a very short time after this, when our fleets were fitting out for the Baltic and Sebastopol, and I also sent them a plan to take Cronstadt, and how to fire concentrated broadsides; and I stated that I had tried these balls many years before, and on the coast of Spain. In 1812 I invented the sights combining the elevation and lines of sight in one focus. It was brought out seven years afterwards by an artillery officer, and is now called a military invention. This had wings, which were intended to prevent the shot wabbling in the gun, because a conical ball without wings, when it leaves the muzzle of the gun, would wabble. Mr. Lancaster took off the wings, and tried the conical ball before the Queen and Admiral Berkeley, at Spithead; and, in consequence of the wings being taken off, it diverged from the axle of the gun, and injured the lighthouse. Finding that was the case, they capsized the ball, and fired it so that when it left the gun it performed a somersault like Grimaldi.

This is a gun (*showing a model*) that I invented; it has two grooves only, and the conical ball has four. These two have zinc attached to them to fill up the grooves, the other merely fills up the bore of the gun. When the ball is sent home, it is turned out of the groove into a slot, and, on being discharged, offers the same resistance as an expansion ball. This is supposing you wish to have it rifled, because it is not decided yet whether you are to have it rifled or not. I load it from the breech, so that the men are not exposed to rifle firing through the ports; because, even in these iron vessels, they

* A model of Admiral Tayler's gun and conical shot may be seen in the Museum of the Institution.—ED.

must have their ports open occasionally. There is a small cone, and there is a slot inside; and, as you bring home the cartridge, this cone fits into the slot, and of course there is no escape of gas inside, and the men are not so exposed in loading the gun.

This is my fuse, which will answer every purpose. If a vessel is within a yard or at three miles, you have only to turn round the inner case, tighten the screw, and it will explode by time at 1, 2, 3 miles, and by concussion during its flight. There was a shell with a military fuse invented after this, and the Government took it up and adopted it. It was probably very good on shore, where you are firing with a fixed gun; but it is not at all adapted for the naval service, because you had to bore out the hole according to the distance, and then you handed it to the captain of the gun, and, by the time he has loaded, two steamers advancing towards each other or separating, would make a difference of a quarter of a mile, and, if you loaded one broadside, and the vessel came up to the stern of you and held off on the opposite side, it would remain in the gun and be no manner of use afterwards, and you could not draw it, therefore you must throw your shot away.

Admiral HALSTED: How many years is it since you proposed that fuse?

Admiral TAYLER: It was in 1840 I proposed conical balls, and the fuse I invented in 1854, I think.

Mr. RICHARDS, of 2, Caroline Street, Bedford Square, then read a paper in which he recapitulated some of the desiderata of a naval gun, and an extract from the specification of a patent which professes to supply them.

Captain FISHBOURNE: Mr. Chairman, ladies, and gentlemen,—I am afraid I shall have to claim your indulgence, for the subject is important. Perhaps I may reverse somewhat the order as to the names of the persons to whom I allude. As Mr. Haddan did not offer any remarks on my paper, but merely referred to a very important subject—that is, the material of which guns should be made—I need not say anything in reference to his mode of rifling. The subject he brought forward is a very important one—I mean, the subject of metals; and the carrying out of his experiments may certainly lead to very satisfactory and economic results. It has been objected to Mr. Haddan, that he has been asked to make a large gun of the metal he referred to, and he has been unequal to do it. The answer, I dare say, many of you read in the *Times* of to-day (I have had no conversation with Mr. Haddan myself), that is, the impossibility of a private individual undertaking the works necessary for constructing guns of that description. Mr. Clay, in describing Mr. Horsfall's monster gun, told you of his difficulties in constructing it, and the greater facilities he has now, for constructing a gun of that kind; and I must say I do entirely sympathise with those various inventors who have had difficulties thrown in their way. There is boundless expense entered into, to try experiments that give no prospect, I think, of success; and experiments that do offer much prospect of success have not been carried out. Mr. Bashley Britten said little or nothing, either, as to the points that I raised with respect to his rifling. He brought forward an interesting subject, drawing a contrast between his guns and Sir William Armstrong's, in which he carried me with him entirely; and I sympathise with him, that he has not had the opportunies of trying it more effectually than he has had. Mr. Lancaster objected that the diagram did not exactly represent the degree of ovality that he now approves. Well, I was dealing with Lancasters as they are, not with Lancasters as they might be. All I can say is, I have no interest in the matter. I have no desire to set forward any one. I wanted to see the best gun; and it was partly because I was independent, and had no crotchet and no hobby to ride, that I was solicited to undertake this paper. If Mr. Lancaster will produce the best gun, the best rifled, and the best in all particulars, we shall hail it with joy. We want a best one, for we have not got it as yet. I thoroughly concur in what Mr. Lancaster said, when he was dwelling upon the question of cast-iron and wrought-iron guns, built-up guns of that description as shown in Plate I. fig. 2, that they are not fitted to undergo the rough work of ship guns. We all know that there are circumstances under which a ship, to save herself, is obliged to throw her guns overboard, and recover them again. I ask, in what condition those guns would be, if they were thrown overboard on rocky ground? Again, it often happens that they have to land the guns to fortify a point. It does not always happen that they have the facilities for hoisting them into the boats, and there is a great deal of rough work in dragging them over the cliffs. I want to know how it is to be done by that gun. Apart from the way in which Sir William Armstrong treated the subject, saying, "Well, it had stood," I may ask, what was my argument throughout my whole paper? It

was not as to what it had stood. I said it had not at all had the test it ought to have, or to which it must necessarily be put, if it is to give the high initial velocity we must have at all cost. There are two or three remarks made by Colonel Lefroy, which I did not answer at the time, and which I think it necessary and important to answer. For instance, Colonel Lefroy cited as proof, that Sir William Armstrong's gun was a suitable gun for naval service, that various Continental nations had adopted it; but he did not add that no naval power has adopted it. Russia, France and America have studiously avoided it. Then again, in respect to the manner in which Colonel Lefroy commented upon my paper—and I must also join with him, Sir William Armstrong—it was, I think, not fair. Thus, for instance, I am made to say on each occasion by them what I did not say, and they have answered what they have undertaken to say for me, rather than what I did say. Upon the subject of strength, Colonel Lefroy says, that as for my exception to the strength of the gun, why, it has proved itself sufficiently strong. Now, I did not say it was not strong. I did say it was strong; but what I did say was, that it was not strong enough to bear the high charges that it will have to bear, if it is to give us the initial velocity that is wanted. Those are two different things; and I particularly use in my paper this expression, that it would burst prematurely-if it were subjected to these high charges. Why, Colonel Lefroy says so himself. "Oh," he says, "it will bear these charges, because we have tried it; but," he says, "you cannot continue it, because it will burst." Why, the proof of the pudding is in the eating, and he has given us an illustration of it. Then, with respect to stripping. He says that I stated, that if you attempted to give it the high initial velocity, it would strip, or that it would be dangerous to the gun—that it would not take the rifling, in fact. Now, Colonel Lefroy answers, that the guns have all been subjected to proof charges, and that their missiles have taken the rifling. What do we mean by rifling? and what do we mean by a rifle? We mean by a rifle that which performs the functions of a rifle, that is, it gives rotatory motion, and continues that rotatory motion, in order to get accuracy of fire. Now, I say, you may have any kind of rifling you please, or any kind of marks upon the missile; if it does not perform the functions of a rifle—that is to say, give and continue that rotatory motion, so as to establish precision—it is not a rifle practically. Such is the fact with respect to this. Table K represents a series of trials; mind, not high velocities, but such as is due to a very small increment of powder; for instance, from 1·75 lbs. to 1·50 lbs.; and the series is continued alternately, so that there can be no doubt of the accuracy; because, of course, with thirty rounds the piece gets hotter, and, if they did not alternate, it would not be fair. Now, what is the fact? We find that, just in proportion, every time as the higher charge is used, so it becomes less accurate. (See table.) The correctness of this may be gathered byan examination of the columns of Table K. headed "Charge" and "Mean Observed Deflection," contrasting column 9 with 15, which contains the results with an iron shot. So that there is a regular law established, that just in proportion as you increase the initial velocity, and increase the quantity of powder, so the rifling slips. It is evident here. [Pointing to a French shot and one of Mr. B. Britten's on the table.] Here is where the slip takes place. Anybody who looks at this, will see the slip here. On each side of these buttons there is the evidence of the slip. There is a series of these tables to prove what I say; and if it were not as I state, Sir William Armstrong is perfectly sensible of the value of initial velocity, and would have obtained initial velocity if he could have obtained it. He would have put more powder, if either the missile or the gun admitted it.

Then, as to the velocity. I do not say that they could not attain high velocity; I said, relatively as high as smooth-bore guns. Colonel Lefroy cited, in a very triumphant tone, "that they had got 1,746 feet from a rifle shot," whereas from an old round-shot 9-pounder they only got 1,613. Now, I might adopt the tactics of that fine old fellow Sir Richard Keats, when he got in between two enemies off Algeziras—he just backed astern, and let the two enemies fire into each other, for he had other work to undertake. If I turn to the *Times*, I find that Sir William Armstrong admits the whole question, that a smooth-bore has a greater initial velocity; and you remember last night he stated it again. So that what are we to say? Here is Colonel Lefroy, defending Sir William Armstrong, saying that his missile gets the higher velocity, and Sir William Armstrong, on the other hand, admits the whole question, and says that it is not so. Well, I think I need not say anything more about Colonel Lefroy.

Sir William Armstrong commenced his remarks by saying that I had no experiments, and he brought as his experiments just the record of *an* experiment. I would ask, what are all these but records of experiments? (Pointing to the various tables against the wall.)

## TABLE K.

I.—Report of Ordnance Select Committee on Practice with Armstrong and Whitworth Guns, alluded to by the President, page 122.

3759 { 1671 B. Armstrong's B. L. 12-pr. Gun, *versus*
{ 1943 C. Whitworth's B. L. 12-pr. Gun.

With reference to *Minute* 3625. Report of Practice submitted.

Object,—To ascertain range and deflection of Whitworth's B. L. 12-pr. Gun, in comparison with Armstrong's 12-pr. Gun.

| Date. | No. of Rounds. | Charge. | Elevation. | Armstrong's 12-pr. B. L. No. 6. Weight .... cwt. 8 qrs. 2 lbs. 11 Length .... 7 feet 6 inches. | | | | | | Whitworth's 12-pr. B. L. No. 1. Weight .... cwt. 9 qrs. 3 lbs. 0 Length .... 8 feet 8 inches. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Range. | | | Mean diff. of Range. | Mean Observed Deflect. | Mean Time of Flight. | Range. | | | Mean diff. of Range. | Mean Observed Deflect. | Mean Time of Flight. |
| | | | | Min. | Max. | Mean. | | | | Min. | Max. | Mean. | | | |
| 1861 | | lbs. | degs. | yds. | yds. | yds. | yds. | yds. | seconds. | yds. | yds. | yds. | yds. | yds. | seconds. |
| 2nd April. | 5 | 1·50 | 2 | 1108 | 1150 | 1130 | 12 | 4 | 3·4 | 1159 | 1223 | 1198 | 19 | 1¼ | 3·5 |
| ,, | ,, | 1·75 | ,, | 1226 | 1307 | 1256 | 26 | 5 | 3·6 | 1266 | 1344 | 1289 | 28 | 1⅞ | 3·4 |
| ,, | ,, | 1·50 | 5 | 2128 | 2165 | 2146 | 11 | 9 | 6·8 | 2072 | 2486 | 2367 | 119 | 1¼ | 6·9 |
| ,, | ,, | 1·75 | ,, | 2331 | 2399 | 2358 | 15 | 11 | 7·3 | 2335 | 2644 | 2471 | 97 | 1⅞ | 7·0 |
| ,, | ,, | 1·50 | 10 | 3512 | 3597 | 3568 | 24 | 12 | 9·8 | 4137 | 4318 | 4222 | 68 | 3 | 10·2 |
| ,, | ,, | 1·75 | ,, | 3866 | 3961 | 3908 | 41 | 17 | 12·9 | 4348 | 4449 | 4399 | 25 | 6⅜ | 13·1 |

Elevation by Quadrant. Guns mounted on Travelling Carriage, on Lieut.-Colonel Clerk's Platform.
Armstrong's Gun. Wads choked in Cartridge.—Whitworth's Gun. Powder and Wad contained in Tin Case.
Weight of Wad, 2 oz. 4 drms. Weight of Tin Case, 8 oz. 8 drms.

Is not Table K an experiment with the Armstrong and Whitworth? These are taken from Colonel Lefroy's own book. Every one of these are experiments, and they might have been multiplied to any number. And yet he says, I have no experiments; and, lo and behold you, he brings *one*. Then, with respect to the shunt gun, Sir William Armstrong objected to the diagrams, I had not given a fair measure of it, and so on. They were all measured by Mr. Vavaseur. He is a constructor of guns; he is perfectly conversant with them; and, so far from doing Sir William Armstrong any injustice, that given is the most favourable specimen of the large shunt family (see Plate I. fig. 9). If I were to have taken some of the earlier patterns, the windage would have been much larger; and, instead of Sir William Armstrong occupying the place he does in Table H, his name would have been considerably lower. When you consider that Sir William Armstrong was asked to speak on this occasion, and he asked for longer time; for there was such a multiplicity of figures that he really must get up figures, in order to be able to refute mine! If I was speaking upon my horn-book, I would not have to ask for time; and one would have thought that there was nothing here that he was not thoroughly conversant with. Sir William Armstrong affects to make light of the ricochet. Major Owen, R.A., in his lecture delivered here, does not do so, though he is favourable to rifled guns. Here is an extract from some information given before the House of Representatives in America: "Captain Dahlgren lays great stress on the certainty of large round projectiles *en ricochet*, which is most useful on water, and his 11-inch shells, weighing 135lbs., are certainly very formidable against wooden ships." I recollect an anecdote with respect to the value of ricochet. One of the steamers employed on the coast of Spain could not get in — I do not know precisely why, but she could not fire direct, because of an intervening point of land, upon the town; but she fired upon a cliff that was facing the town, and threw her shot very effectually into it. Now, I should like to know how Sir William Armstrong's shot would ricochet into that? They would not at all. Yet he attaches no value to the circumstance of ricochet! Then he seemed to throw a great deal of doubt upon this American experiment. Now, here is this work—Simpson on Gunnery—from which Table E is taken; anybody can read it; it is very interesting, and I think it bears evidence of the truth. The proof of it is, evident from his own gun. He wants to say this experiment is of no value, in order to disparage my statements with respect to the value of reducing the windage. But what is the fact, both with respect to Mr. Bashley Britten's gun and with respect to his? Why, because they reduce the windage, or because they reduce it so as to destroy the windage altogether, they produce great results with small charges. Why, that is just what takes place here. Either Sir William Armstrong does not produce results that he says he does, with small charges—there is not that extreme tension upon his gun, by explosion in his gun, that he states there is—or else this table is true. Then, if it is true, it is monstrous to draw a comparison between old guns with very large windage, and his guns that have no windage at all. He went into a long argument last night, to prove that it was a question of weight, not of friction. Now, here are some experiments that prove the very reverse. If it was the weight that was the cause of the higher initial velocity, then, instead of getting 1,809 feet initial velocity with the 51-lb. 8-inch shell, and 1,579 with the 66-lb. shot, these figures would be reversed (see table B). He says that the effect of the weight retaining the shot in the gun so much longer increases the elasticity of the powder to such a degree that it overcomes and gets a greater result. Why is it not shown so here? Here is the greater weight, and here is the less initial velocity. The fact is, that there *is* friction, by which, and by giving rotatory motion, power is absorbed, as any one who believes in mechanical laws must admit.

Sir William Armstrong undertakes to say that I said that the trajectory in this diagram, (Plate I. fig. 13), was that of his shot—of his ball. I did not say so. Here is my paper, in which what I did say is written. I simply supposed the case of a shot that would travel a distance of 600 yards in one second; and I supposed the case of another shot with less initial velocity, or half the initial velocity, that would require two seconds to travel the same distance. Then I drew *that* as an illustration of what would be the result. I, of course, gave Table C *a*, Appendix, also; but there I gave the actual quantities, and pointed to the actual quantities. The lines (see Table) represent the point-blank ranges of these respective guns, as given by the authorities. I am not in the least responsible for them. The table was prepared by Mr. Clay, and it must be taken for what it is worth. The principle is just the same. If, on the contrary, instead of taking only one second and two seconds, where the difference between fall by gravity is the difference between 16 and 64, I had taken the difference

between two and three seconds, there the difference would have been greater, because it would have been the difference between 64 and 144 feet. Now, Sir William Armstrong repeats a statement, and I must say it is deserving of comment, and of strong comment. We can understand a person at a meeting, getting up and speaking hastily, and extemporally, using an expression that is not quite to the point, or giving a fact that is not relevant; but when Sir William Armstrong asks for time, and when a fact such as it was—for it was a fact of its kind, but not a relevant fact—was given by Colonel Lefroy with respect to the rifle as compared with the round shot, and Sir William Armstrong hears that, and then twenty-four hours afterwards repeats that, I say it is deserving of comment. Now, what are the facts concerning that? The meeting was led to suppose that this was an accurate rifle projectile, such as is used in ordinary service. It was not such. Here is the paragraph which appears in the paper, "It has been the fashion of late, on the part of those who have studied gunnery, to assert that the initial velocity imparted to a shot from a rifled cannon is less than that which would be derived from a smooth-bore gun. Sir William Armstrong joined issue on this point, and, in order to settle the matter, he, on the day alluded to, loaded a 12-pounder, on his principle, with a shell weighing 8 lbs. with a 2 lb. charge of powder, and the initial velocity obtained was 1,740 feet. A 9-pounder smooth-bore was then loaded with a shot of 9 lbs. and 2¼ lbs. of powder, and the initial velocity amounted only to 1,613 feet."* The first position is this. I stated that elongated rifle balls could not be projected with the same initial velocity as round balls, and I stated the reason. The greater weight, and the wings, or rifling, would prevent the one from being projected with the same velocity as the other. Now, here is not an ordinary rifle projectile. His ordinary rifle projectile for this piece is 11lb. 12oz. He reduces that down to 8 pounds. How does he do it? He must cut it in various ways. He must cut it shorter; and I have no doubt he reduced the lead. He reduced a great deal of the friction; and in fact he reduced it as far as possible to the conditions of a round ball; and then he fires it against a round ball, out of an old 9-pounder, with all its windage, while he reduced all the friction of his own.

Mr. G. RENDEL: No, no.

Captain FISHBOURNE: Well, comparatively.

Mr. G. RENDEL: The shot was not reduced in any way.

Captain FISHBOURNE: Are you prepared to say that?

Mr. G. RENDEL: Certainly.

Captain FISHBOURNE: Perhaps you will explain afterwards how it was?

Mr. G. RENDEL: I have nothing to explain, except that the shot was not reduced.

Captain FISHBOURNE: Then what was it, may I ask?

Mr. G. RENDEL: You say the shot was turned down.

Captain FISHBOURNE: Perhaps you will explain. I am not anxious to mislead in any way. Perhaps you will kindly explain what was done.

Mr. G. RENDEL: I merely say that the shot was not reduced.

Captain FISHBOURNE: I say it was reduced from 11lbs. 12oz. to 8lbs. Will you describe how it was reduced?

Mr. G. RENDEL: I will, if you will allow me. You stated that the lead was reduced at the back, to take away all the friction. Such was not the case.

Captain FISHBOURNE: That was my impression.

Commander SCOTT: It was a specially prepared projectile, not the ordinary one. Perhaps you will state what it was. Let us have the fact.

Mr. G. RENDEL: I merely wished to correct one important statement that was likely to mislead the meeting.

Captain FISHBOURNE: Will you state the whole facts? Because that is really the point to be arrived at. I do not want to mislead the meeting.

Commander SCOTT: Describe the projectile.

Mr. G. RENDEL: I am not in a position to describe the whole facts, but I hear things stated that are not correct. I understand you to say that the lead is turned down at the base of the shot, with the view of reducing the shot to the condition of a shot fired from a smooth-bore gun. I believe that such is not the case, and, as it is an important feature in the experiment, I think it right to say so.

Captain FISHBOURNE: You reduced the weight.

Mr. G. RENDEL: I know nothing of the weight. I know there is a 9-pounder shot fired from a light 12-pounder gun. There is such a shot as a 9-pounder, and I believe

* See Army and Navy Gazette, May 17, 1862.

that must have been the one used in the experiment, not a special shot constructed for the purpose. You would lead the meeting to suppose that a special shot was made for this experiment, and that I call in question.

Admiral HALSTED: When you use the term "turned down," do you use it in the sense of reducing the diameter, paring down?

Mr. G. RENDEL: I am answering Captain Fishbourne.

Captain FISHBOURNE: I understand it was a 12-pounder gun, and not a 9-pounder, that you spoke of.

Mr. G. RENDEL: It is the same calibre; and the size of the gun is stated.

Captain FISHBOURNE: Gentlemen, I am not in a position to tell you. What I say is this, that the meeting was led to believe that this was an ordinary service projectile; that an elongated rifle shot was projected, and produced the velocity of 1,740 feet. Neither did Colonel Lefroy nor Sir William Armstrong say anything about the reduction of the weight at all. Now, what I complain of is this, that in a public meeting of this sort, men in the public service, upon a public question, with one of Her Majesty's ministers in the chair, should undertake to get up and state half the facts.

Commander SCOTT: As the meeting has been interrupted on this occasion, I may claim from the Chairman permission to say this, that the 9-pounder is served out as a 9-pounder, and never mentioned as a 12-pounder. The 12-pounder gun is issued as a 12-pounder. I never heard a 9-pounder called a 12-pounder in my life, and I do not know that it has ever been.

Mr. G. RENDEL: The 9-pounder is simply a 12-pounder shortened.

Commander SCOTT: It is a different gun which has been supplied, in consequence of the other gun being too heavy for the horse artillery. I know it quite as well as you do. It is a 9-pounder.

Captain FISHBOURNE: What I contend is, that under any circumstances it is a one-sided experiment, and I want to know why one-sided experiments are to be made; and I want to know why, after one-sided experiments are made, they are given publicity to in the public press, when experiments that are of immense value and immense importance, that make altogether in the opposite direction, are kept covered up. Sir William Armstrong affected to throw discredit and doubt upon Table E. I had a great many more facts of this description. I did not want to crowd them upon the meeting. The first part of Table G was in the *Times* newspaper; others were taken from measurement at Shoeburyness and the official reports, and Sir William Armstrong affects to say that these are not accurate. The principle on which the numbers given in Table A, and headed comparative force of blow, are calculated is the admitted principle, that the resistances of iron plates are as the squares of their thicknesses. These figures are only inverting the operation, and taking the indentation, and squaring that, as giving a measure of the force of the blow which made those indentations.

There is another fact that I do think Colonel Lefroy and Sir William Armstrong, more especially Sir William Armstrong, when he was talking upon this very important question, should have told us at the same time, and that was a fact which he kept quietly from us; and certainly, by what he said, he led us to believe that there was no such fact in existence. It is this: that from a smooth-bore gun, with a 150 lb. shot, 2,000 feet velocity was obtained. Now, I dare say most of the persons present do not know that such an experiment has been made at all, and I do say it is one-sided for Colonel Lefroy and Sir William Armstrong to speak about the wonderful velocity of 1,740 feet got from his gun, and to speak of it as the greatest velocity. I do not actually use his words, but certainly that was the impression left behind, that it was greater velocity than was obtained from the smooth bore, when we have the smooth bore giving 2,000 feet instead of 1,740. It is quite true, there was a large quantity of powder, but it was a smooth bore. That is the question at issue. His rifle guns will not bear the amount of powder that was fired out of these smooth-bore guns; and the whole question turns upon this.

Admiral HALSTED: Allow me to make one remark. The charges from which these initial velocities were got, were all fired by galvanic battery; and in the case of the 80 lb. and 90 lb. charges, they were fired from two different places. The length of the cartridge amounted to about two feet, and two wires were put in, with about the space of eight inches between them. The cartridge was therefore divided into three parts. That is how that initial velocity was obtained. Otherwise it was utterly impossible for a gun of that description to have burned 60, 70, 80, or 90 pounds of powder during the period of the passage of the shot from the breech to the muzzle. Therefore, all these velocities are perfectly abnormal.

Captain FISHBOURNE: I think, Admiral, you are a little beyond the book; because Sir Howard Douglas gives an initial velocity of 2,200 feet.

Admiral HALSTED: I merely stated how it was obtained.

Captain FISHBOURNE: But you went beyond, and said that was a velocity that was purely abnormal.

Admiral HALSTED: I meant that mode of firing the cartridge was perfectly abnormal. It is usually fired from the touch-hole.

Captain FISHBOURNE: I beg your pardon. It just comes to this—that, notwithstanding the objections which Sir William Armstrong undertook to refute, I am not aware that the audience will say that he has refuted a single fact or a single statement that I have brought forward; I do not know that he has undertaken to do so directly; he has cast, as I said before, a doubt upon Table E; but there it is. Here is the work:* the man will speak for himself. Any person who reads this book will be, I am sure, satisfied as to the character of it; and it is really a representation of facts, and it is just as much an experiment, and I say a far more accurate experiment, than that, in which 1,740 feet initial velocity was obtained; and I think you will observe that Sir William Armstrong acknowledged that in the end we must have smooth bores for ship's broadside guns. I am quite satisfied of it myself. I am quite satisfied that it is not with lead-coated projectiles, or lead in any shape on projectiles, that you can at all get the initial velocity that will suit for ship guns, for breaching purposes, at short distances; and therefore if you cannot from strong missiles of this description [pointing to an iron shot with iron bearings] get the initial velocity you want, you have no alternative but to have smooth-bore guns; and I think it is quite evident that this is the conclusion Sir William Armstrong has come to himself; but I do say, and I do feel—and I think any persons who consider about it, will agree with me—that, seeing the number of crotchets Sir William Armstrong has had upon the subject, it is hardly fair to leave our service any longer at the mercy of his further crotchets. I do feel most strongly that the question ought to be an open one, and that experiments by other people ought to be admitted, that there should be an independent body to determine what the experiments should be, and to see them carried out. Why, what is the fact? Here we have these old service guns, that have done us good service, condemned by wholesale, just upon the mere fiat, that "this will not do," or "that will not do;" in the same style in which he condemns this, "Oh! this is impossible, it cannot be; I give you no reason for it." As if we were all children that we must accept his dicta, just because he chooses to say it. Why, really it is quite sad. A criminal, if he only goes to the judge *in formâ pauperis*, has a counsel appointed to defend him, but here these poor smooth-bore guns, with all their disadvantages, have the judges and jury and counsel and spectators all against them. No wonder they are condemned and thrown out of court. I do say the country would never get better worth for a fee, than if it were to appoint a person or suitable persons to watch these experiments and see that they are proper experiments and properly tried. Would any one believe that Sir William Armstrong, who demonstrates to you, and writes to the *Times* newspaper on, the importance of initial velocity, should systematically neglect it? There is not one experiment that is made, except those lately, in which the grand object has been to get greater initial velocity. Every experiment has been "how not to do it."

I am sorry I have troubled you so long on the matter. I have hardly made it as clear as I should like to have done, because it is a large subject and it is not my subject. There are many others who would have undertaken the subject much better, and done much better by it; but it might have been said that they had a crotchet, or a hobby to ride. I have none.

The CHAIRMAN: Having now brought this discussion on the best naval guns to a conclusion, I may mention that the Council have before them the subject of the best metal for a naval gun, on which they hope to elicit equally valuable information as they have done on the present occasion. As soon as it is arranged, they will advertise when the discussion is to take place.

A vote of thanks was passed to Captain FISHBOURNE, for his paper, and the proceedings terminated.

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* Ordnance and Naval Gunnery. By Lieutenant Simpson, U.S. Navy.

Since the above discussion took place a 9-pounder Armstrong segment shell and a 12-pounder Armstrong proof shot have been deposited at the Royal United Service Institution, by Colonel Lefroy, R.A., with the undermentioned description, to illustrate his remarks:—

"1.—9-pounder Armstrong segment shell (weighing without fuse or bursting charge 8¼lbs.) This specimen has been reduced to 8lbs. by removing 4oz. of the inside metal, and is one of those prepared for a determination of the initial velocity of an Armstrong shot fired with a charge of one-fourth its weight, May, 1862.

"For charge 2lbs., the mean velocity was:—

1,662 feet per second with $A_4$ powder.
1,746 feet ditto with $2_4$ A powder.*

2.—12-pounder Armstrong proof shot, fired with a charge of one-fourth its weight. Exhibited to show that shot fired with this charge take the rifling.—Ed.

* $2\,A_4$ powder has a much larger grain than $A_4$.

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We are requested by Captain Fishbourne to add the following explanatory note:—

"Understanding that Colonel Lefroy has sent an Armstrong 12-pounder shot, and a 9-pounder segment shell, reduced to 8 lbs. to be deposited in the Institution to prove the correctness of his statements, I beg to add that I did not question his facts, but their relevancy to my statements.

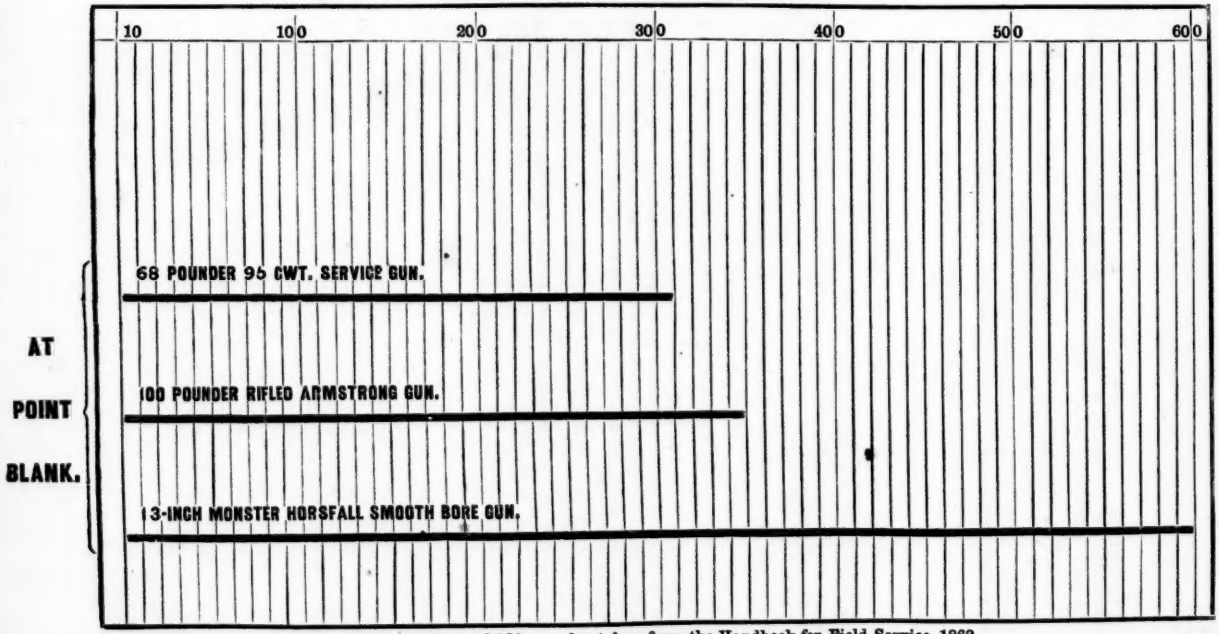
"I did not say that under exceptional circumstances, and with velocity greater than usual, the Armstrong shot would not take the rifling; my statement was, that if elongated lead-coated shot were driven up to the maximum velocities obtainable with spherical shot, the former would slip, or burst the guns if the coating were hardened, and I especially alluded to heavy naval guns, which are fired with high charges for breaching iron plates.

"The experiment with the 8 lb. shell was irrelevant, as I did not say that a high velocity could not be given to an elongated shot under any circumstances; but that to an elongated shot could not be given a velocity equal to that given to a spherical shot under the conditions stated in my paper, in which I dwelt on the necessity for heavy guns and high charges for ship purposes.

"The following would have been relevant to my paper, and would have been a useful and a scientific experiment:

"A spherical shot with the smallest practical windage fired from a gun of equal diameter, and precisely similar to the 110-pounder (but with a smooth bore), and with a charge that would bring equal tension upon it with that which the 110-pounder multi-groove is subjected to, when fired with the highest charge it will *safely* bear."—Ed.

## TABLE C*a*.—RANGES IN YARDS.




Ranges of 68-pounder and 100-pounder taken from the Handbook for Field Service, 1862.
The range of the Horsfall 13-inch Gun taken from the official Report to the War Office dated 5th February, 1857.
Height of axis of bore above the plane, the 68-pounder gun not stated.
" " 100-pounder Armstrong 17ft.
" " 13-inch Horsfall 20ft.